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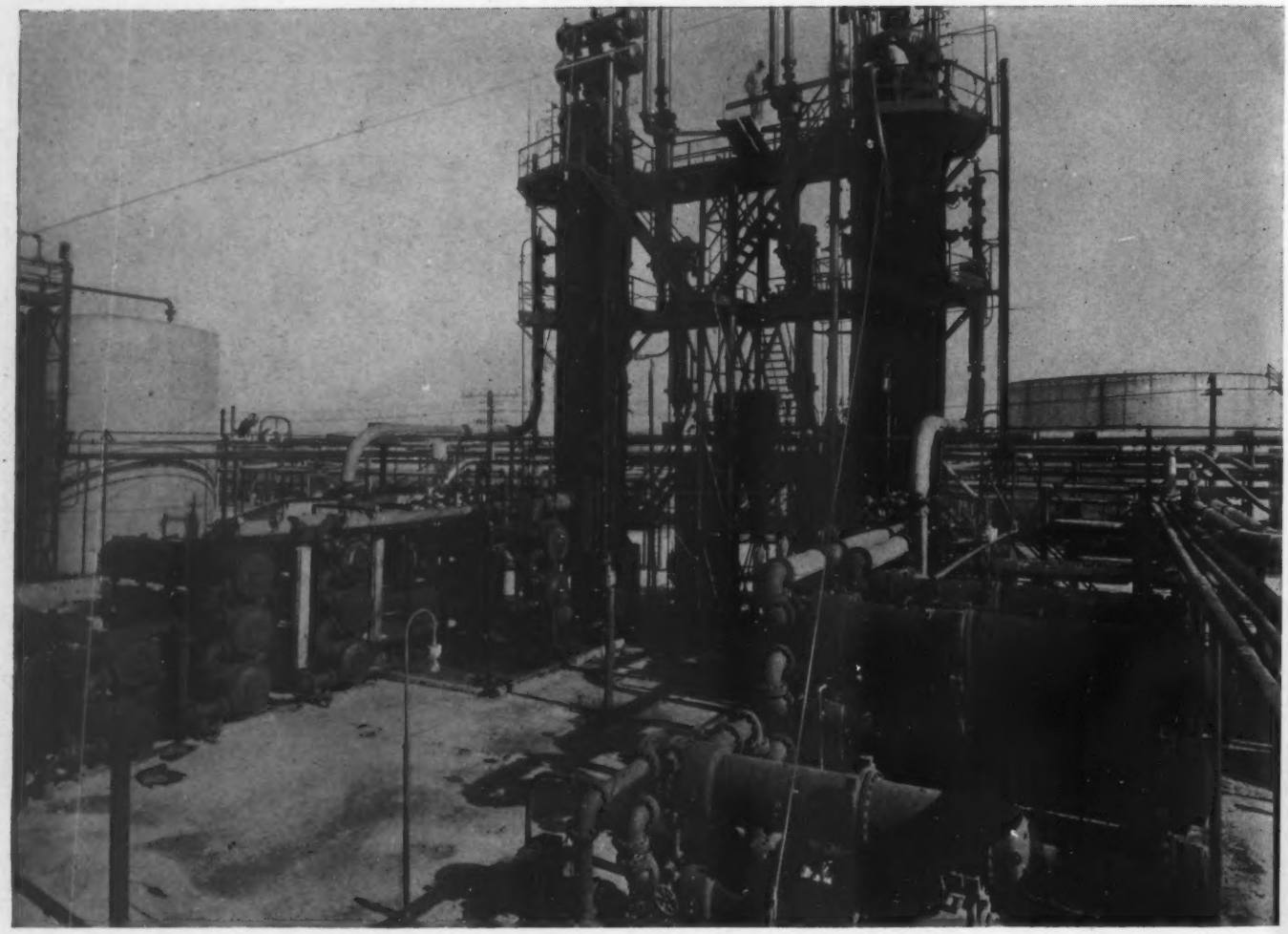

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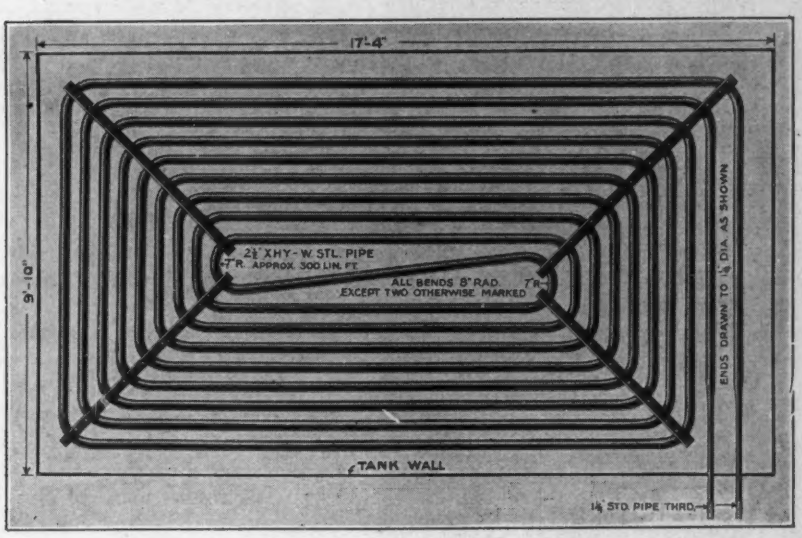

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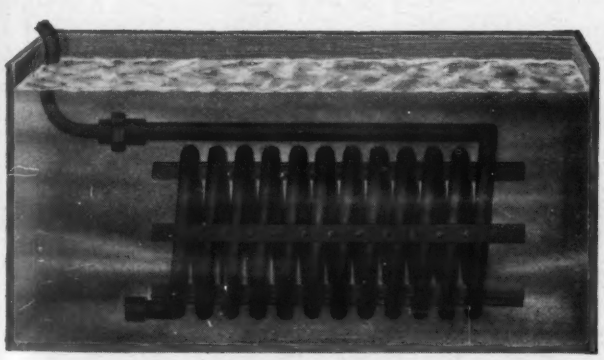

EACH individual Pittsburgh Coil is tested before shipment—tested under heavy air pressure while completely submerged in water. "There isn't a leak in a mile of Pittsburgh-built Coils."

ELECTRICALLY welded, continuous — no couplings, no pipe fittings. That is the way Pittsburgh Coils are built for oil country and refinery use.

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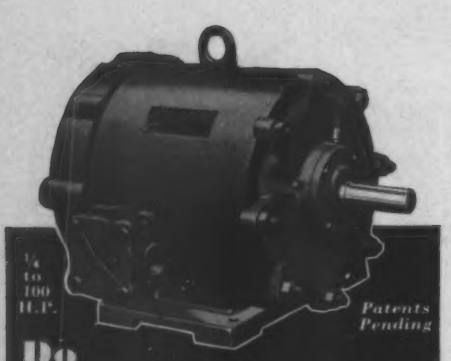

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THE MONTH IN REVIEW

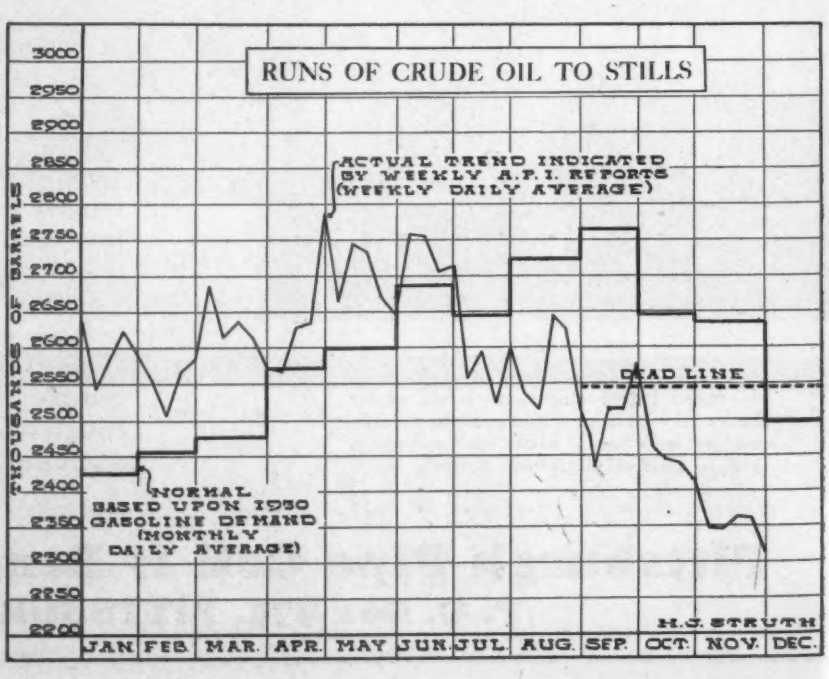
In the following columns will be found a brief digest of happenings of interest to refiners, even with reference to a rumor or two!

BUREAU of Mines figures for the month of October show that motor fuel production during October declined 25,000 barrels daily from September. Slackening demand, however, resulted in a gain in stocks of gasoline of 430,000 barrels; the total on October 31 amounting to 38,684,000 barrels. Stocks of all oils, including crude oil, declined during October to the extent of 3,678,000 barrels. This decline compares with a gain during the same period of last year of 4,579,000 barrels. Crude production declined for the fifth consecutive month, bringing the daily average production for October down to 2,345,000 barrels.

REFINERY runs of crude to stills during the week ending November 29 were reduced to the lowest point this year, when American Petroleum Institute figures showed that the total had been brought down to 15,724,000 barrels, or a daily average of 2,246,000 barrels. On a Bureau of Mines basis, this represents a daily average throughput of 2,313,000 barrels. The results obtained by refiners in bringing operations under the present degree of control are indeed gratifying. If still runs schedules are maintained at this level for any length of time, it is obvious that stocks of gasoline will be materially reduced over a period of weeks when the industry would ordinarily be building up inventories against spring demands.

DELIVERIES of gas and fuel oil during 1929, as reported to the United States Bureau of Mines by refining and marketing companies, reached a total of 408,735,493 barrels, including exports and shipments to non-contiguous territories. This compares with a total of 397,650,767 barrels in 1928; 381,662,801 barrels in 1927; and 372,650,767 barrels in 1926. An increase of 16,352,786 barrels, or 4.63 per cent, was reported in deliveries within the United States. Shipments to foreign countries and non-contiguous territories decreased 5,277,388 barrels. The largest gains in domestic consumption were recorded by railroads, steamships, oil refineries and electric power plants. Commercial and domestic heating gas and fuel oil requirements during 1929 reflected the extension in the use of oil as fuel in the heating of buildings.

EXPORTS of petroleum and its products for the first 10 months of this year were valued at $416,039,185, against $446,811,051 during the same period of last year. This represents a decline in value of $30,771,866, reflecting to some degree the lower prices which have prevailed during 1930. Analysis of detailed export figures show, however, that this decline was not all due to low market values, but partly due to a slump in volume of oil exported. In fact, gasoline was the only product to show a gain in



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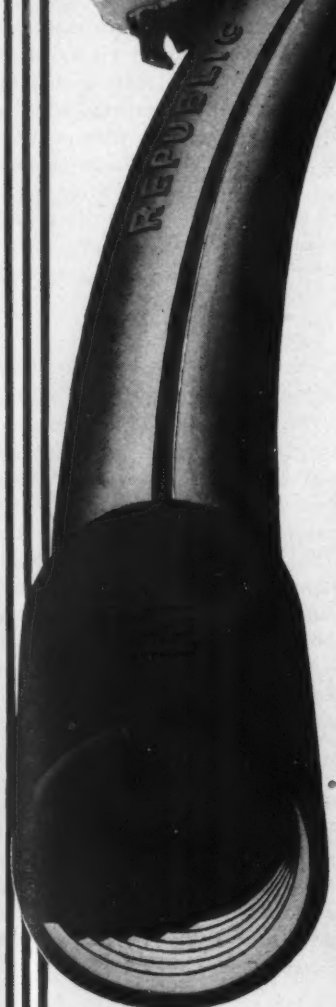

By no other standard can the true value of Toncan Iron Pipe be gauged properly. Compared with ordinary pipe—in measurements of 365 days—the longer life of Toncan Iron Pipe is most convincing. It is a trouble-free pipe of highly refined iron, copper and molybdenum, with permanence processed into every tiny grain of metal. Use the 365-day yardstick to determine how much any pipe will cost—and Toncan Iron Pipe certainly will cost less.

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DIXONS INDUSTRIAL PAINTS

The Month In Review

quantity exported during this period. The value of gasoline exports, however, was lower than last year by $764,735, despite a gain in volume exported over last year of 5,327,017 barrels. All other products and crude oil exported showed a decline in volume as well as in value.

NATURAL gasoline production during 1929 aggregated 2,233,688,000 gallons, according to final official statistics prepared by the Bureau of Mines. This output represents an increase of 23 per cent over 1928, as compared with an increase of 11 per cent in 1928 over 1927. The average annual increase in natural gasoline production over a period of the past 10 years is 21 per cent. The report shows that there was a pronounced tendency to erect larger plants in 1929 and, while the recovery per thousand cubic feet af gas treated was below the average, the larger quantity of gas put through the plants had a material effect on the total output for the year. The rapid growth in utilization of natural gas during 1929 was another stimulating factor in natural gasoline production. Because a large amount of gas was blown into the air after treatment during 1929, the quantity of natural gas treated for gasoline recovery represented 102 per cent of all the marketed production of natural gas.

UNION Oil Company is reported again making a survey of the business and properties of Richfield Oil Company with a view of acquiring that company through an exchange of shares. Such negotiations were undertaken some time ago and stopped when Tide Water Associated Oil Company entered the picture with designs on Richfield Oil Company. These plans have not been dropped but certain obstacles having developed encourages Union Oil Company to again investigate. Advantage to Union Oil Company in the merger is acquisition of Richfield Oil Company's important marketing facilities which require more crude oil for the company's refineries than its producing division supplies; Union Oil Company on the other hand has sufficient crude for those needs and a merger would mean cancellation of Richfield Oil Company's committments to buy crude when contracts expire.

PROPERTIES of Chestnut & Smith Corporation and subsidiaries in Texas will be sold to Lone Star Gas Company, Dallas, Texas, if stockholders are favorable at a special meeting December 16, at Tulsa. The proposal is that

FOR THIRTY-NINE YEARS . . .

Long, continuous service is assured with Homestead Quarter - Turn valves on the job, for they are cast in brass, iron, steel, acid resisting bronze, monel, or other metals to resist the action of specific fluids at specified temperatures and pressures.

Engineers have recognized the fact that Homestead Quarter-Turn Valves stop costly leaks, give longer, continuous service, and lower maintenance costs.

They have found thru long experience with Homesteads that these savings are made possible by the carefully ground metal to metal seating surfaces, sealed bottom and bonnet, and the quick, positive cam seating action.

It is these features that help to put an end to valve troubles and afford industrial plants the long low-cost valve service that they desire. It is also these features that quickly offset and justify the higher first cost of Homesteads.

If you, personally, have not yet experienced the satisfaction and savings afforded by Homesteads either by using them in your own plant or by specifying them on your consultation jobs, it will pay you to investigate them at once.

Catalog number thirty-five will help you in writing Homesteads into your next valve specifications. Write for your copy today.

You can add Homestead Valves' low maintenance advantage to most any piping layout because they are made in straight-way, three-way and four-way types—sizes up to 12"—for pressures as high as 3000 pounds.

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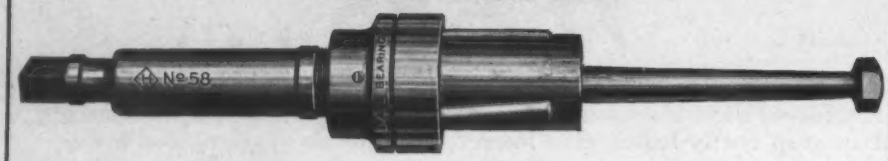
Heavy Duty Expanders for Still Tubes



Tools for the Oil Industries

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Tube Expanders for Cracking Still Tubes
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They clamp to any tank or vat in one minute and produce a more thorough, rapid mix . . . . more economically than by any other process. Capacities from five to 50,000 gallons.

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ALL LIQUID CHEMICALS

ALSOP ENGINEERING COMPANY
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New York City

The Month in Review

37,500 shares of Lone Star Gasoline Company (organized for the purpose) six per cent cumulative stock, (par $100.00) will be paid for the physical properties in Texas and at Westwego, Louisiana, of Chestnut & Smith Corporation, Smith-Hanlon, Inc., Brooks & Hanlon, Inc., and Naturaline Company of America. A further detail is that Chestnut & Smith Corporation will transfer to Bancamerica-Blair Corporation the $3,750,000 in Lone Star Gasoline Company stock, receive $3,125,000 in cash and payment of $250,000 liabilities of Chestnut & Smith Corporation and its subsidiaries.

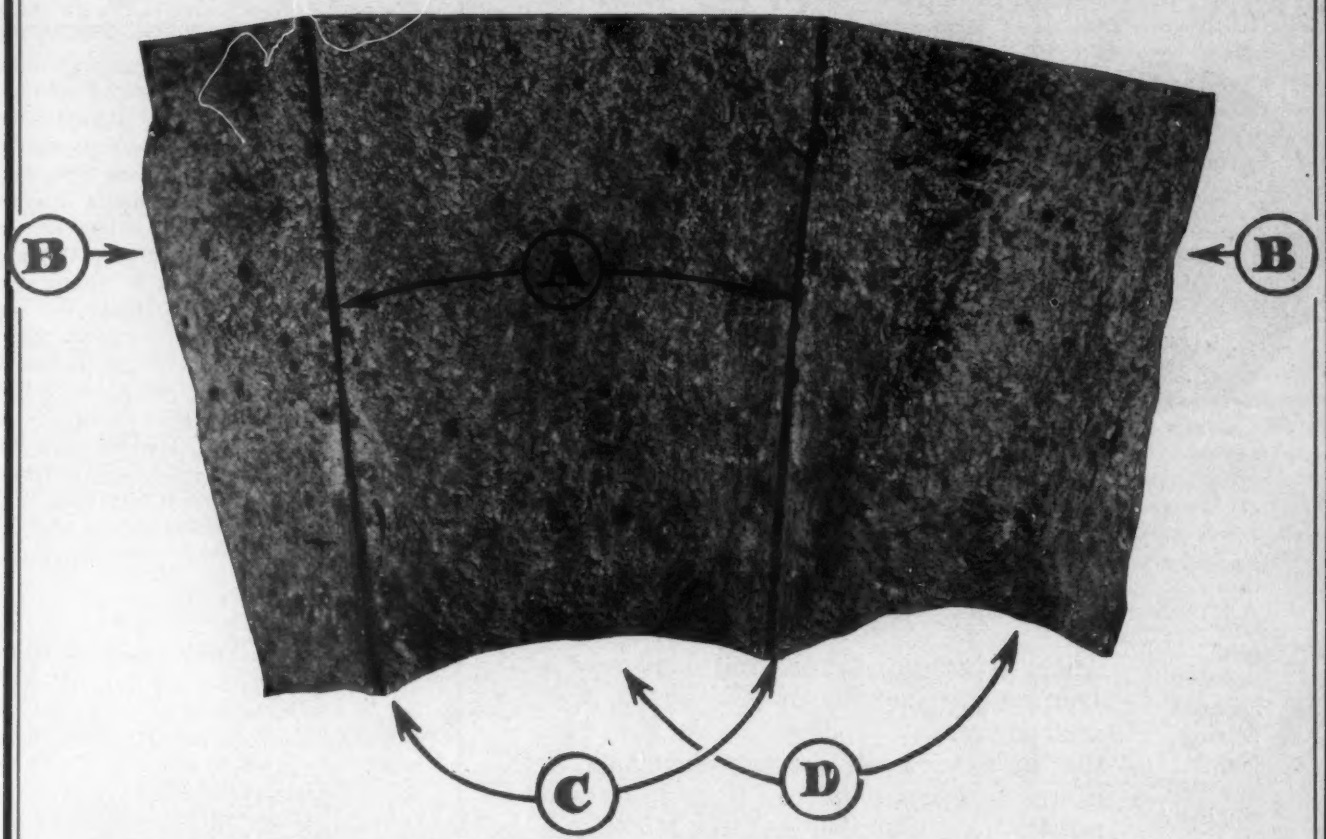
PRESIDENT Hoover's oil policy as applied to government lands has been upheld by the District of Columbia Court of Appeals in a decision upholding the action of the Secretary of the Interior in rejecting around 5000 pending applications for prospective permits. A lower court had ruled with seekers of permits that a presidential statement to the press was not sufficient to authorize the secretary to conserve oil in government preserves. An appeal to the supreme court is in prospect. In his annual report, Secretary Ray Lyman Wilbur said that the oil industry received no real injury by reason of the policy; that more wells were shut in on government property than new brought into production during the period covered by the report.

OKLAHOMA and Texas lost heavily in gross production taxes by reason of curtailment of production and reduced prices of crude petroleum. Reports for the third quarter of 1930 show that the average price of oil at the wells in Oklahoma was $1.36, in Texas $1.07, per barrel. Texas, because of substantial royalties on state lands, is hardest hit. This circumstances, in part, explains the two states' willingness to cooperate with producers in correcting the economics of oil production.

PRAIRIE Oil & Gas Company, long dominating the crude oil market in the Mid-Continent, has announced withdrawal as a purchaser, effective January 1, following drastic curtailment during December of movement of its own and purchased oil through lines of its subsidiary Prairie Pipe Line Company. Originally a Standard unit, the Prairie companies have been removed from that association and later connection by building of a line by Ajax Pipe Line Company from the Mid-Continent to the Middle-West and Eastern connections and acqui-

How are Your Arches Holding Up!

Compare the next ARCH that falls or is torn out, with section illustrated below — *this ARCH was laid in KROMEPATCH.*



A Thin even KROMEPATCH joints bond brick into a monolithic structure. Note absence of crumbling, fluxing, bubbling and squeezing out of KROMEPATCH.

B In tearing out this section, the brick broke while KROMEPATCH joints remained intact. The joints are stronger than the brick.

C KROMEPATCH protects brick by resisting destructive elements, preventing penetration at joints. Note how joints project, proving conclusively that KROMEPATCH is more resistant to abrasion and destruction than brick themselves.

D Brick wear back in center (concave) while strong KROMEPATCH joints project, giving protection where it is most needed and thus increasing service life of arch.

Remember:—

Joint failure is caused by either crumbling or melting of bonding material.

Crumbling joints (material that lacks bond) allow heat to penetrate, exposing corners of brick which crack and fall out. This action repeats itself and soon joints are wide open and you need a new arch. Joints made of clay base cements (lacking refractoriness) soften at low temperatures and flux sides of brick. Bonding material and fluxed brick bubbles from joint allowing heat to penetrate. Result—joints deeply cut out and short arch life.

KROMEPATCH Cement is primarily chrome ore—does not crumble, squeeze out or flux brick. Use it and avoid short ARCH and refractory lining life.

KROMEPATCH does prolong the service life of furnace linings.

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"Pioneers in Chrome Refractories"

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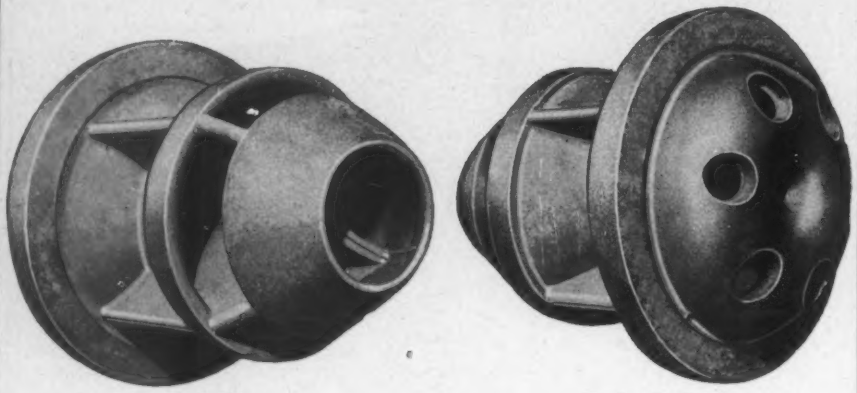

Inlet End View *Outlet End View*

DURIRON Mixing Nozzles treat light oils and lube stock, make up emulsions and blend, with one-third the pressure drop required with orifice plates.

One acid resisting Duriron Mixing Nozzle will eliminate six or more orifice plates.

They eliminate maintenance expense, as Duriron is chemically inactive to the acids used in refinery processes and it is so hard that its surfaces are not scored by high velocities or gritty solutions. *In a word, these nozzles do a thorough and economical job.*

Complete data—method of installing, sizes, prices, etc.—sent on request.

THE DURIRON COMPANY, INC., DAYTON, OHIO

DURIRON

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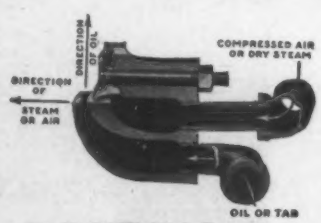

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W. N. BEST Oil Burners

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dependable, efficient, economical, non-clogging atomizers of fuel oils, tars, acid sludges and still bottoms.

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The Month in Review

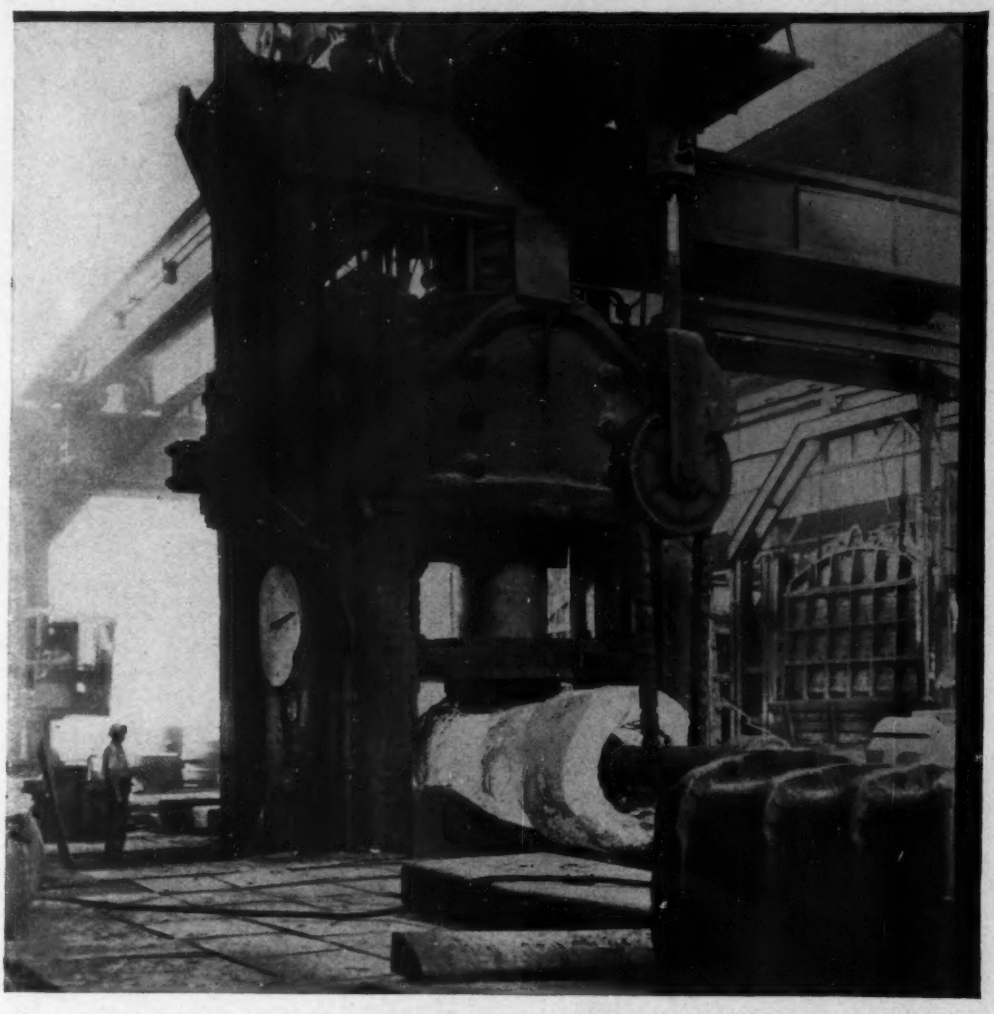
sition of Standard Oil Company (Indiana) of full interest in the line heretofore operated jointly with Sinclair Consolidated Oil Corporation; Standard Oil Company of New Jersey in the last three years has been moving more oil from the Gulf Coast by water to eastern plants. Rumors of Sinclair Consolidated Oil Corporation acquisition of the Prairie lines have abated and Sinclair interests apparently have plans for a new pipe line organization. In the meantime, Prairie Oil & Gas Company has 60,000,000 barrels of crude oil in storage, an asset that becomes a stumbling block to selling the system to Sinclair which could use the pipe lines; does not want the oil, many barrels of which has been in the tanks through several price revisions. Withdrawal of Prairie Oil & Gas Company as purchaser will work a hardship on many producers in near-depleted fields in Oklahoma and Kansas where the remaining prospects for production do not warrant lines by other buyers, especially under present conditions.

OIL and gas well completions in the United States for the month of November, 1930, exclusive of Rocky Mountain states, aggregated 1233 wells, compared with 1199 wells in October. The number of producing wells completed increased from 587 in October to 627 in November, while dry hole completions showed a gain of 23 and gas well completions a decline of 29 wells. Initial oil production during November amounted to 729,651 barrels, against 615,002 barrels in October. The initial volume of gas obtained from new gas well completions during November amounted to 1,359,025,000 cubic feet, against 1,775,050,000 cubic feet in October.

CRUDE oil production during the month of November, according to a preliminary estimate compiled by THE OIL WEEKLY,* aggregated 68,675,600 barrels, compared with 73,627,650 barrels in October, a further decline of 4,952,050 barrels. Texas continued to be the largest producer of crude oil in the United States, with a total output for that month of 22,237,700 barrels. California retained second place with a total production of 18,036,100 barrels, while Oklahoma came third with a total production of 14,781,500 barrels. Daily average crude oil production in the United States during November was 2,289,186 barrels, compared with a daily average during October of 2,375,050 barrels.

* A Gulf Publishing Company Publication.

FORGED
FROM A SINGLE INGOT



NO seams, no joints where there might be a question mark instead of a known factor—Midvale forges *seamless* pressure vessels, made from a single steel ingot!

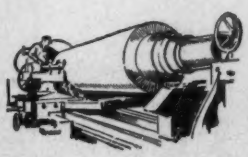
Builders and operators of high pressure cracking units are interested in the strongest, the safest type of vessel that can be produced. Midvale was a pioneer in this type of vessel, and Midvale's research laboratory and experienced shop men continue to carry pressure vessels' capacity to higher limits—over wide ranges of diameters, lengths and wall thicknesses.

The Midvale Company is at your service at any of its offices—Philadelphia, New York, Washington, Pittsburgh, Cleveland, Chicago or San Francisco.

MIDVALE

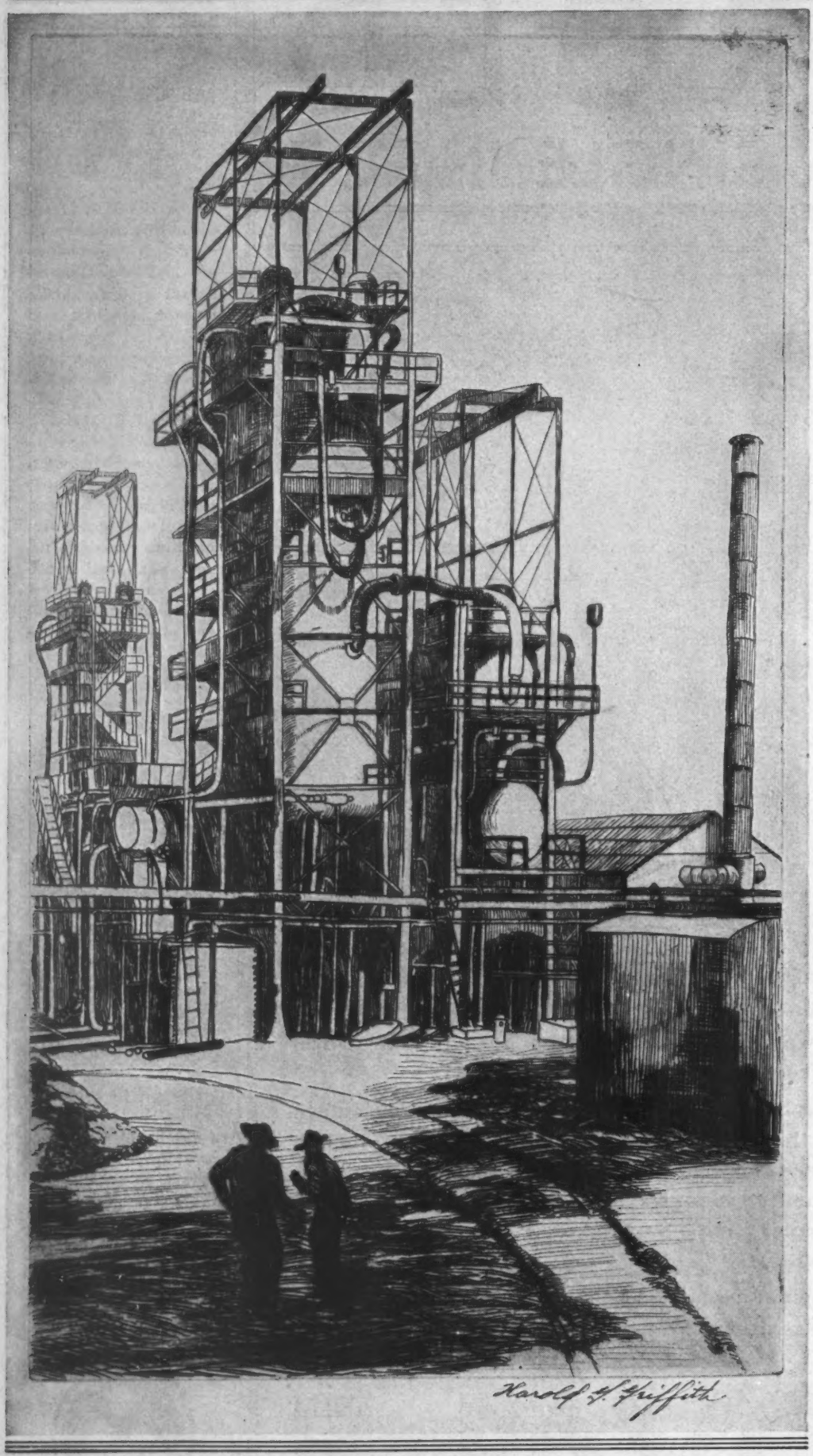
MIDVALOY HR

Midvaloy H R fits a surprising number of needs. Its heat-resistant and corrosion-resistant qualities make it both efficient and economical for high temperature operating conditions. Successful installations with Midvaloy H R include: continuous furnace parts, retorts, boxes, recuperator tubes, stoker grates, tuyeres, chains, slicing links, sulphide roasting furnace parts, oil refining furnace parts, cast pyrometer tubes and gas industry equipment.



TOOL STEEL

Midvale does not follow the "tonnage" method of tool steel production. Midvale charges with cold metal. Lets the ingots cool, to permit inspection for faults. Carefully chips out any cracks. Reheats ingots and reduces billet size. Sand-blasts the scale. Again inspects and chips when necessary. Reheats and rolls to finished size. This is the only method by which tool steel of Midvale quality can be produced.



Courtesy of The Guardian Trust Co., Cleveland, Ohio.

MODERN BUBBLE TOWERS at the Standard Oil Company (Ohio) operating with OCECO One Piece Cast Iron Trays and OCECO Bubble Caps in connection with 1000 pound cracking unit.

These OCECO towers produce direct from the cracking unit, gasoline which requires no re-running and no acid treatment. The Oil Conservation Engineering Co., 877 Addison Road, Cleveland, Ohio.

A Gulf Publishing Company Publication

THE REFINER

and Natural Gasoline Manufacturer

Member Audit Bureau of Circulations

VOL 9, No. 12

DECEMBER, 1930

GRADY TRIPLETT, *Editor*

GEORGE REID, *Associate Editor*

CONTENTS

The Month in Review 56

Rectification of Natural Gas Hydrocarbons 67
By I. N. Beall

Reclaiming Absorption Oil as Aid to Plant Efficiency 74
By C. D. Gard

Editorials 76

Institute's Refining Sessions Growing in Importance 77
By George Reid

Catalytic Reactions of Organic Sulphur Compounds 83
By Hugh S. Taylor

Color Control 89
By H. M. Weir, W. F. Houghton and F. M. Majewski

Flue Gas for Reducing Fire Hazard 122
By H. E. Pew, Jr.

Plant Men and Methods 150

Refinery and Gasoline Plant Activities 155

New Equipment for the Modern Plant 163

Items About Manufacturers 170

Index to Advertisers 178

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HERE'S another company which agrees that Cooper-Bessemer Type-80 compressor units are without equal in their class. The photograph shows 36 of these four-cycle gas engine driven compressor units after they had been in service for about four years in Plant No. 13 of the Sinclair Oil and Gas Company, located in the Seminole field. (Some of these engines have recently been moved to other plants.)

THE COOPER-BESSEMER CORPORATION
MT. VERNON, OHIO GROVE CITY, PA.

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

VOLUME 9, No. 12 DECEMBER, 1930

Rectification of Natural Gas Hydrocarbons

By I. N. BEALL

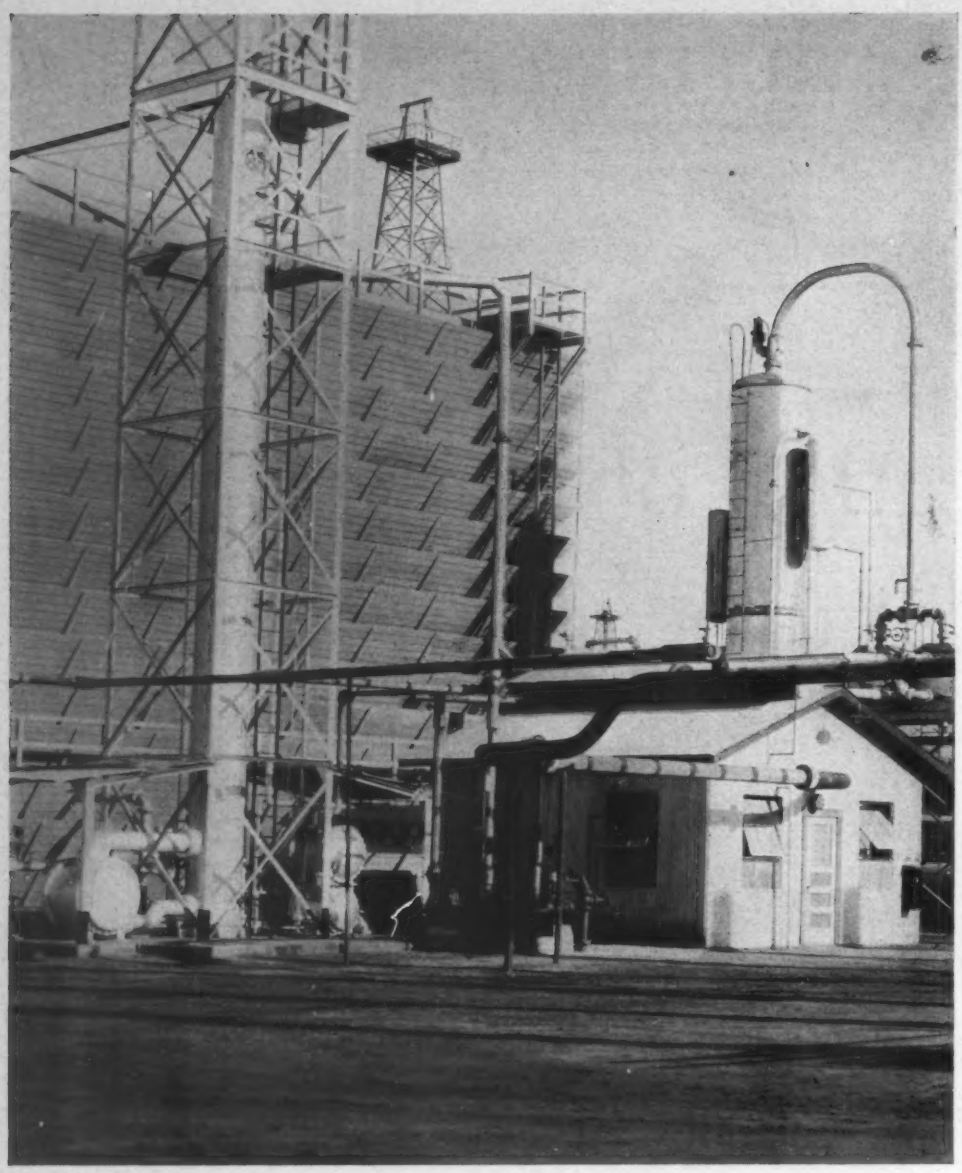
THIS constitutes the seventh of a series of articles by I. N. Beall, chemical engineer, dealing with the practical application of technology and engineering data to the manufacture of natural gasoline.

In this work the writer centers his discussion around the problems of rectification as they apply to the preparation of liquefied petroleum gases. After setting forth the more or less familiar fundamentals of hydrocarbon constituents of natural gas, Mr. Beall deals with the interesting problems concurrent with the separation of special fractions. Factors contributing to successful operation of this type of plant such as number of columns, temperature and pressure requisites, and operating procedure are discussed. The effect of pressure and temperature, uniformity of raw material, process steps and finished product, the number of plates required per column, and critical temperatures and critical pressures, are discussed in so far as they apply to or influence the problem at hand.

A further article will incorporate a discussion of the separation of isomeric hydrocarbons by fractionation and will constitute the second part of Mr. Beall's discussion of the rectification of natural gas hydrocarbons.

NATURAL gas is predominantly composed of hydrocarbons belonging to the chemically saturated series, the simplest of which is methane. Of those hydrocarbons which are desirable constituents of natural gasoline, butane is the most volatile. Intermediate between butane and methane, there are ethane, propane, and isobutane. Other possible intermediates might include cyclobutane which belongs to the naphthene series. Cyclopropane, because of its apparent instability, is not believed to exist as a constituent of natural gas. Butane lies on the division line between those hydrocarbons which are gas and those hydrocarbons which are liquid under normal conditions of temperature and pressure. Isobutane has the same composition formula as butane—the differences in physical and chemical properties are due to differences in structure. With the ascension of the hydrocarbon series, the number of compounds corresponding to the same composition formula increases, there are three hydrocarbons of the pentane formula (C_5H_{12}) all differing in chemical and physical properties. The number of compounds for the formulas C_6H_{14}, C_7H_{16}, C_8H_{18}, C_9H_{20}, $C_{10}H_{22}$, are five, nine, 18, 35 and 75 respectively. If only part of the isomers for the members higher than pentane were present in any one gasoline mixture, separation by fractionation into pure constituents would still be difficult. The specific gravities and boiling point range of some natural gasolines would seem to indicate the presence of the cyclo-saturated compounds, particularly among the higher boiling portions. Natural gas is not always a simple mixture of a few hydrocarbons; the higher content wet gases are frequently very complex.

It is becoming more and more desirable to separate natural gas into other prod-



A Rectifying Plant

ucts than natural gasoline. Within the last few years, special products, such as aviation gasoline, liquefied gas for industrial and domestic consumption, butane for artificial gas enrichment, pentanes for the manufacturer of alcohols and other organic chemicals, have become of industrial importance.

The fractionation of natural gasoline hydrocarbons differs only from other types of fractionation in that low temperatures or high pressures must be used. The principles of fractionation require that both liquid and gas phases exist in equilibrium; this applies to every plate of column. The feed to the average column contains constituents of such volatile nature that only the gas phase would exist were it not for high pressure or low temperature. Fortunately all the hydrocarbons with the exception of methane may be liquefied at ordinary temperatures by an increase of pressure. This means that at ordinary temperatures all hydrocarbons, such as ethane, propane, isobutane, butane, etc., may be separated by fractionation.

Those hydrocarbons heavier than methane and lighter than pentane are especially adaptable to high pressure fractionation. Methane can best be separated by selective absorption. For each hydrocarbon, there exists a critical temperature which is the temperature above which no amount of pressure will produce the liquid phase. The pressure which produces liquefaction at the critical temperature is the critical pressure. The critical temperature of a mixture of gases is dependent upon the critical temperature of its components. The approximate formula for the critical temperatures of a mixture is

$$Tm = \frac{P_1T_1 + P_2T_2 + P_3T_3}{100}$$

where Tm is the critical temperature of the mixtures, p_1, p_2, p_3 and t_1, t_2 and t_3 represent the mol percentage and the critical temperatures of the com-

ponents respectively. For a binary mixture the formula is

$$Tm = \frac{pt_1 + (100-p)\,T_2}{100}$$

For example the critical pressure of ethane is 95°F, and for the propane 207°F. The critical temperature for a 60-40 ethane-propane mixture would be

$$\frac{(60 \times 95) + (40 \times 207)}{100} = 139.8°F.$$

The critical pressures for ethane and propane are 666 and 663 pounds per square inch. In order to calculate the critical pressure of the mixture it is necessary to take the hypothetical vapor pressure of ethane from an extrapolated curve and the vapor pressure of propane at 139.8°F. and use Raoult's formula for vapor pressures of liquid mixtures. It is obvious that a liquid mixture can be compounded to any desired vapor pressure specification between the limits of the critical constants. Ethane, as well as propane, isobutane, and butane, are suitable as liquefied gases provided they are admixed with a sufficiently less volatile hydrocarbon to assure that the critical temperature will not be exceeded in shipping, storage, or utilization.

The lighter hydrocarbons above methane are easier to isolate by rectification than the heavier hydrocarbons above butane. There are two reasons why this should be so:

(1) Because of the greater difference in volatility between consecutive hydrocarbons; (2) the absence of isomers other than isobutane.

There are three pentanes, normal, isopentane, and neo-pentane. These may be separated by distillation into practically pure form. This will be discussed more fully in a later article on the separation of isomeric hydrocarbons by fractionation.

NUMBER OF COLUMNS

If it is desired to effect a close separation between n fractions, n — 1 column will be required. Thus in order to resolve a mixture of propane, isobutane and butane into pure components, two columns will be used. The separation would be performed as follows:

The operating pressure will be set for propane, the maximum possible to carry is 663 pounds per square inch which would correspond to a temperature of 207°F. on the top plate. This pressure is much higher than necessary for purposes of fractionation. Any pressure on the vapor pressure curve of propane may be selected as the operating pressure provided it corresponds to the range of reflux condenser temperature. Where the overhead condensate is to consist essentially of propane, propane is used as reflux to the top plate. The same holds true for both partial condensers and forced reflux. Reflux should always consist essentially of the most volatile product which it is desired to separate, for a mixture of isobutane and butane, isobutane is used as a reflux. The proportion of more volatile component in the liquid on the top plate is always less than that in the vapor above it, this holds true for every plate in the column. By increasing the amount of reflux, the purity of the overhead condensate will be increased but a heavier load will be thrown on the column. A delicate balance exists between column capacity and the quantity of reflux.

Referring again to the assumed mixture of propane, isobutane and butane, where a separation is sought between the constituents, propane will be

A GREAT deal of Mr. Beall's discussion of rectification and fractionation of natural gas hydrocarbons is applicable to problems confronting the designer and operator of refinery fractionation equipment as well as natural gasoline extraction apparatus. This is especially true in the departments of the refinery where special light products are fractionated and in conjunction with gasoline recovery (vapor recovery) plants and units designed for the isolation of special hydrocarbons from cracking still gases and the like.

It is not unlikely that many refiners will find it profitable to prepare liquefied petroleum gases in connection with their gasoline recovery installations as the market is developed and demand is increased for such products. Further, with the installation of increasing numbers of cracking units, both liquid and vapor phase, with corresponding increases in gas production from such units as every higher anti-knock quality is demanded, then the rectification of these gases for the recovery of unsaturates and other series useful in synthesis, will become of greater importance.

Mr. Beall, in his series of articles dealing with the practical application of technology to the manufacture of natural gasoline, of which this is number seven, has many times contributed valuable working data for the refinery engineer, and has discussed pro and con much of the design and application of various pieces of equipment employed in petroleum refining; and although the series is primarily prepared for the natural gasoline plant engineer, expressions from refinery engineers over the past few months in regard to the material presented, indicate a like interest in that phase of the manufacturing branch of the petroleum industry.

passed overhead to the condensing system from column Number 1 leaving the residue mixture of isobutane and butane. The vapor pressure of this residue mixture must be equal to, or exceed, the operating pressure, if it is to be freed of propane. This mixture will be sent for separation to a second column in which the operating pressure is less than in Number 1, if a logical procedure is to be adopted. Fortunately the mixtures of a normal hydrocarbon with its isomers obey Raoults Law almost quantitatively, which fact materially assists in the accuracy of column design for this purpose.

A great many natural gasoline plants would benefit by the use of two columns even though natural gasoline is the only product marketed. Excess butane over that required in the gasoline necessitates a fractionation that will proportion the amount overhead to that left within the product, a rather difficult feat. The usual result is that there is a loss in efficiency due to lack of sharp separation, isobutane and lighter remain in part in the product, part of the butane that could well remain goes out with the vapors.

RELATIVE VOLATILITY

To offset the disadvantage of the higher pressures required for the fractionation of those hydrocarbons lighter than pentane, the volatility ratio increases. Selecting a temperature of 86° F. ethane has a vapor pressure of 593.0 pounds, propane 162.0 pounds, isobutane 60 pounds, butane 40 pounds and isopentane 16 pounds. Taking the volatility ratio as the index to the ease of separation, ethane-propane = 3.66; propane-isobutane = 2.70; isobutane-butane = 1.5 and butane-isopentane = 2.50.

These ratios clearly bring out the fact that the lighter and more volatile constituents of natural gas are easier to separate than the higher less volatile ones. Fewer plates are required for a given degree of rectification.

Methane is the only natural gas hydrocarbon not susceptible to fractionation at ordinary temperatures without use of intense refrigeration.

At this point it would perhaps be well to mention that one gallon of ethane at 60° F, has a heating value of 84,100 b.t.u. in comparison, propane at 60°F. has a heating value of 99,400 b.t.u. per gallon. With increased demands for liquefied gas, ethane may attain importance particularly when admixed with propane, isobutane and butane. Therefore it is not considered amiss to discuss facts pertaining to its fractionation.

OPERATING PROCEDURE

There is as yet no outlet sufficiently extensive to utilize all of the ethane, propane, and isobutane contained in natural gas. At the present time there is an excess of butane and isobutane and propane above requirements for liquefied fuel gas and other special purposes. Natural gasoline, because of its widespread use as a blending material for increasing the volatility of motor fuel, is generally the main source of plant revenue, other materials of manufacture are by-products for which there is only a partial outlet.

Under such conditions as at present exist, the operating procedure has for its objective the maximum recovery of gasoline at a minimum operating expense. For a plant having a favorable outlet for all by-products, the operating procedure might conceivably be very different from that now in general use.

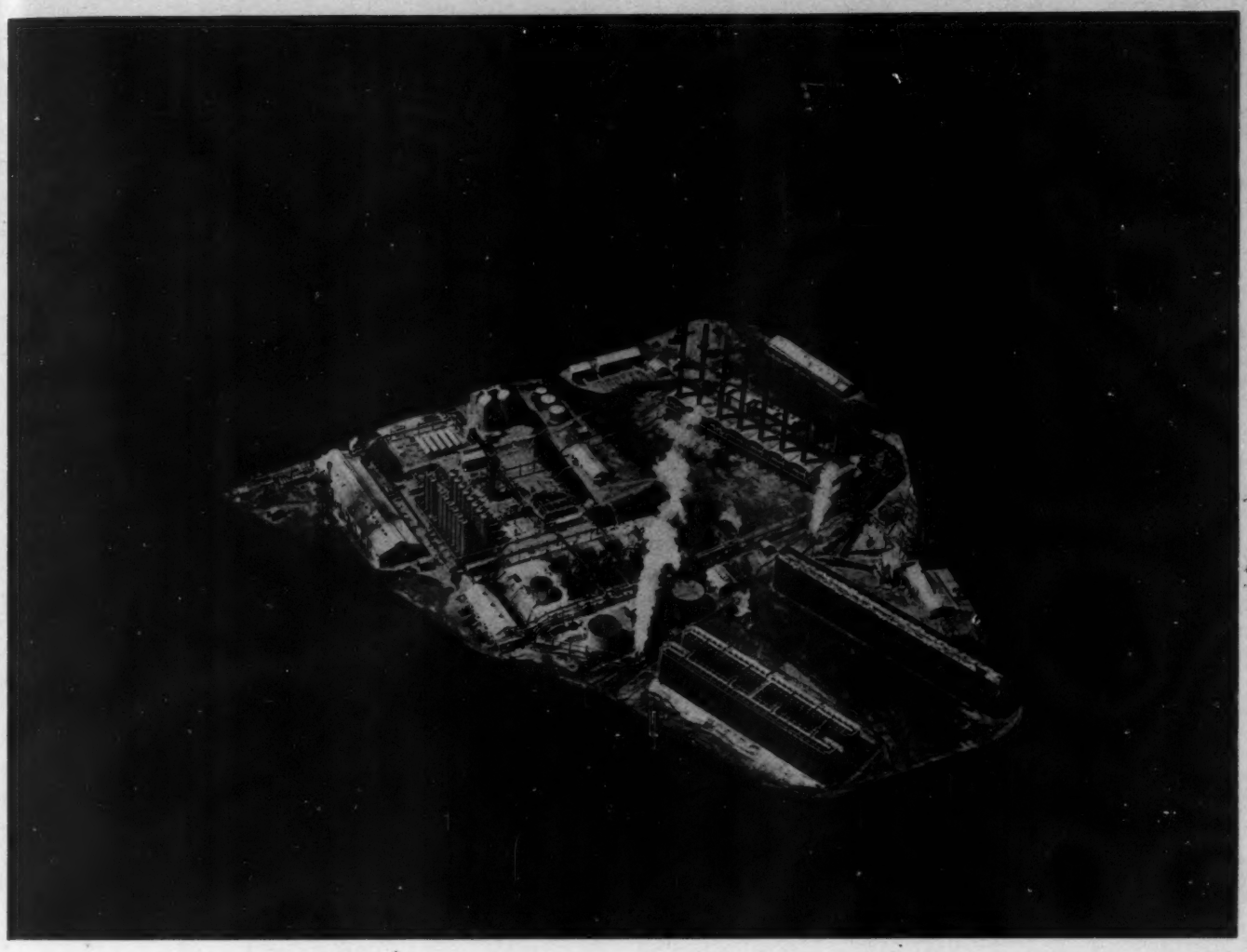
Let it be assumed, for sake of illustration, that a major proportion of those hydrocarbons higher than methane have been recovered from a natural gas by absorption or compression and are sent as feed to a series of fractionating columns. If a deep cut has been made into the ethane, the feed will also contain considerable proportions of methane. The feed is in the liquid state, under pressure, as it comes from the accumulators. As pumps are cheap and their cost of operation low, it would obviously be advantageous to boost the pressures between the accumulators and the first fractionation column in order to separate out by pressure fractionation the lighter constituents which would consist of a mixture of methane and ethane.

In the absence of any specialized use for this first cut, it could be used to advantage as a plant fuel gas because of its relatively high b.t.u. value over that of residue gas from the stripper. The residual ethane together with propane and isobutane can be separated in column Number 2 under a pressure considerably lower than that used in Number 1. Heating will be required between the columns, although a reduction in pressure will cause additional vaporization and cut down on the b.t.u. requirements. Reboilers are used at the bottom of each column. In the above illustration, ethane could be separated from column Number 2, propane from Number 3 and isobutane in Number 4. Another procedure would be to make a split between isobutane and butane, condense the overhead and refractionate it into the desired constituents. The first scheme is preferable where there is need for economical close separation of total constituents lower than butane.

For the separation of the pentanes from a given feed mixture, the split is made between normal pentane and the lowest boiling isohexane. The overhead vapors containing normal pentane and its isomers may pass through a partial condenser which separates out an enriched liquid mixture, this condensed mixture then passing on to a fractionating column for further separation.

EFFECT OF PRESSURE AND TEMPERATURE

When the pressure is increased over a boiling liquid, boiling ceases unless the temperature is raised accordingly. The volatility ratio is a variable with the temperature, the numerical value of this ratio



A Natural Gasoline Plant of the Shell Oil Company of California operating in the Ventura Avenue field

decreases as the temperature is raised. This can be illustrated by taking the vapor pressures of any two hydrocarbons and comparing them at different temperatures. For isobutane and butane the volatility of butane as compared with its isomer is 0.633 at 32°F., 0.721 at 122°F., and 0.767 at 212°F. A similar relationship could be shown for any two hydrocarbons.

From purely theoretical considerations, it can be shown that closer separation can be effected at low temperatures and pressures with a smaller number of perfect plates. It is however more practical to use increased pressure and a greater number of plates as no additional equipment is needed in the way of compressors and refrigerating units. The column capacity likewise increases for a given cross-section as the pressure is increased. The question is no longer between the advantages and disadvantages of low and high pressure fractionation; it is rather a question as to what is the best operating pressure. The answer is that the best operating pressure is the lowest one that will assure liquid and vapor equilibrium on the top plates of the column. Bearing in mind that the reflux to the top plate should consist essentially of the finished product, the operating pressure can be determined from a consideration of the vapor pressures of this product and the available condenser temperature.

It is best to set the condenser temperature high enough to assure that it will take care of the poorer cooling conditions for the hottest days. If it is impossible to cool to less than 95°F. in the summer time, the tower should be able to withstand the corresponding operating pressure required. The lighter the product to be fractionated, the higher the pressures required for its fractionation. In this discussion it is assumed that the temperatures used for condensation to provide reflux are those available by use of the plant cooling water and that the temperature range will be somewhere between 60 and 100°F. Low temperature low pressure columns which depend upon the expansion of portions of the feed mixture for cooling are not considered here as it is the writer's opinion that such columns are not as adaptable, efficient, or economical as those that depend upon higher pressures at ordinary temperatures for separation. Mechanical refrigeration is not considered as the low temperatures that would necessarily obtain where such mixtures as ethane, propane, and isobutane are to be separated would

not warrant its use. Natural gasoline feed mixtures are particularly suitable for high pressure fractionation, the addition of a few extra plates is a small matter when compared to the mechanical advantages which result from an increase of pressure.

UNIFORM PLANT OPERATION

Uniform plant operation is one of the first essentials to good fractionation. If it were possible to have a feed stock of unvarying constituency the problem of designing a fractionating column to meet the requirements, would be simple. Steady flow and unvarying composition of feed are to be desired at all times. Under actual plant operations, such ideal conditions are never attained. Beginning with absorption, difficulties accumulate which are reflected throughout the cycle. The product which finally collects in the accumulator tanks is never the same over two consecutive periods—the daily average would show up better than the hourly average in this respect.

Natural gas as it comes from the wells has not been affected by atmospheric conditions; so the temperature is practically uniform at all times. Wet gases separate "drip" before they arrive at the plant absorbers, the "drip" is high when the temperature is low and low when the temperature is high. If the natural gas could reach the absorbers before any "drips" separated, the absorbed constituents would be more uniform in composition. This, however, cannot be, so the next best bet is to have the drip added in such manner as to help compensate the fluctuations. The next source for variation in final feed material comes at stripping, after which there are variations in condenser temperatures before accumulation.

Other uncontrollable factors enter into the picture to make the problem of final fractionation more difficult. The accumulator tanks act as buffers which help to smooth out the fluctuations,—the greater the capacity of these accumulators, the easier it will be to fractionate the products from them. Large accumulator capacity is the best assurance for steady flow and uniform composition. A goodly portion of the blame that is attributed to faulty fractionator design can be traced back to some other step in the operating cycle.

A reasonable amount of flexibility can be built into a column, but at best, separation by fractionation depends upon delicate equilibrium conditions between liquid and vapor. It is best to adjust a column for one set of operating conditions and avoid continual changes as time is required for the establishment of new conditions of equilibrium.

PLATES REQUIRED

The number of plates required for a given degree of separation may be calculated by a number of different methods. The graphical method of McCabe and Thiele is the easiest to visualize and gives good results. The following illustration will serve to show how separation takes place from plate to plate. (All calculations are on a mol per cent basis as this is the only rational method for such purpose). A 50-50 mol per cent mix of butane and pentane enters the feed plate of a column at a temperature of 150°F; what will be the composition of the vapors rising from such a mixture?

The vapor pressure for butane is found to be 3100 millimeters at this temperature and that of pentane 940 millimeters.

The calculation is $3100 \times .5 = 1550$ $940 \times .5 = 470$

$$\frac{100 \times 1550}{1550 + 470} = 76.7$$ per cent butane in vapor.

From a liquid mixture containing 76.7 per cent butane and 23.3 per cent pentane, allowing four degrees temperature drop per plate, Vapor pressure butane = 2950 mm and vapor pressure

$$\text{pentane} = 890 \text{ mm} \frac{2950 \times 76.7}{(2950 \times .767)} \quad \frac{}{(890 \times .233)} = 91.6$$

per cent butane, etc. If the calculation is continued it will be found that pentane practically disappears from the vapors rising from the plate. In order that fractionation may proceed it is necessary that the liquid boil. This can only occur when the vapor pressure of the mixture exceeds the operating pressure.

TABLE NUMBER 1
PROPERTIES OF LIGHT HYDROCARBONS

Formula	Name	B.P. °F.	Critical Temp.	Pressure at 60°F.	Critical Pressure	Lbs. Gal.	b.t.u. Gal. 60°F.	b.t.u. per Lb.
C_2H_6	ethane	—135	95	475	666	3.58	87,400	24,400
C_3H_8	propane	—49	207	105	663	4.34	102,000	23,500
C_4H_{10}	isobutane	+12.2	273	...	537	4.90	114,500	23,350
C_4H_{10}	butane	31.8	307	35	522	4.87	113,700	.....
C_5H_{12}	neopentane	49.1	...	...	...	5.21	117,200	22,200
C_5H_{12}	isopentane	86.0	370	...	484	5.32	119,600	.....
C_5H_{12}	pentane	98.6	387	6.5	487	5.29	119,000	.....

The above table shows some of the important properties of the lighter hydrocarbons. The boiling points of ethane, propane, and isobutane at atmospheric pressure indicate that mixtures of these compounds are suitable for vaporization to fuel gas at very low temperatures. Isobutane, butane and neopentane are all suitable for bottled fuel gas, the boiling points show that the cylinders should be kept in heated storage for the winter months. The three pentanes are all gases above 100°F. A mixture could be made by blending, having an average boiling point from 135°F. to 98.6°F.

The critical temperatures are high, the lowest, that of ethane is 95°F. All of these gases can be shipped in the liquid state under pressure. Ethane mixed with a small proportion of any of the higher hydrocarbons to raise the critical temperature would safely remain a liquid even in hottest summer weather. If it is assured that the temperature will not be above

125°F. in the shipping container, the amount of any higher hydrocarbon to admix with ethane to keep it a liquid will be found by

$$\frac{95\ p+tc\ (100-p)}{100}=125$$

where p = the percentage of ethane, 100—p = the percentage of higher hydrocarbon and tc its critical temperature. For example to find the percentage of propane necessary to admix with ethane so that the mixture will be a liquid at 125°F.

$$\frac{95p+207\ (100-p)}{100}=125,$$

p=73.2 per cent ethane, 100—p=26.8 per cent propane. If isobutane replaced propane

$$\frac{95p+273\ (100-p)}{100}=125,$$

p=83.1 per cent ethane, 100—p=16.9 per cent isobutane. For isopentane, 89.1 per cent ethane, 10.9 per cent isobutane. It is apparent from the above that there would be no difficulty in the storage of liquid ethane if properly admixed with other constituents.

The maximum critical pressure of any mixture of the above hydrocarbons could not exceed that of ethane which is 666 pounds per square inch absolute. On a gallonage or cubic capacity basis the b.t.u. balance is in favor of the higher hydrocarbons. On a weight basis the b.t.u. balance is in favor of the lighter hydrocarbons.

VAPOR PRESSURES

If a liquid is heated, its vapor pressure will increase until boiling occurs. If the pressure is increased the boiling point increases; as for example when a liquid is heated in closed container. At the critical temperature the liquid phase disappears, further heating can only cause an increase of pressure by gas expansion. Actually there is no such thing as vapor pressure above the critical temperature as by definition of vapor pressure the liquid phase is presumed. It is known however, that the liquid phase does exist above the critical temperatures for pure substances in solution.

For example ethane can exist as a liquid in solution with propane, isobutane, etc., at temperatures above 95°F. Vapor pressure curves usually end at the critical temperature, however, extension is justified as the hypothetical vapor pressure beyond the critical temperatures has a significance for calculations pertaining to fractionation, absorption, and liquid solutions. The maximum percentage of methane that will remain as liquid in solution with propane can be found by the formula already given for critical temperatures of mixtures. For example, what per cent methane can be contained in propane at 86°F. at the critical pressure of the mixture. The calculation is 344 p + 667 (11—p) = 546 x 100 p = 2.6 per cent methane. The temperatures are expressed in the above in degrees Fahrenheit Absolute, 344 is the critical temperature of methane, 667 that of propane. Having determined the percentages of each constituent present the critical pressure can be closely approximated by the use of the hypothetical vapor pressure of methane at 86°F. and the actual vapor pressure of propane at the same temperature. In the absence of specific data based on experimental results, a Cox Chart for extrapolating vapor pressure temperature curves can be used for determining the hypothetical vapor pressures. (E. R. Cox, Journal of Industrial and Engineering Chemistry, June, 1923). Only one experimentally determined point is needed for plotting the curve for any hydrocarbon by this method. The Clausius equation can also be used for the determination of hypothetical vapor pressures.

Previous articles by I. N. Beall in REFINER AND NATURAL GASOLINE MANUFACTURER *of which the foregoing is Number 7 of the series; "Securing Maximum Recovery From Absorption Oils," March,* 1930, *page* 70; *"Absorption and Absorption Oils," April,* 1930, *page* 75; *"Factors Affecting the Operation of Absorption Equipment," May,* 1930, *page* 88; *"Design and Operation of Fractionating Columns," June, page* 86; *"The Fractionation of Absorption Oil," July, page* 88; *and "Fractionation for Absorption Plants," November,* 1930, *page* 86.

Reclaiming Absorption Oil As Aid to Plant Efficiency

By C. D. GARD
Gas Engineer, Union Oil Company

IN modern absorption plant practice, efficiency has become the paramount issue. No longer do plant designers and operators guess at those factors which govern the operation of their equipment and control the quantity of gasoline production collected in storage tanks. Instead we find these men vitally interested in the fundamental principles which so closely affect that branch of the petroleum industry which is engaged in the extraction of natural gasoline fractions from natural gas. In their respective order we have had the development of the multiplate absorbers, the fractionating stills and finished gasoline rectifiers. Now we find the absorption oil reclaimer on the list of necessary absorption plant auxiliary equipment.

During the past few years the quantity and quality of the absorption oil required have been receiving increasing attention. Some rather rigid specifications have been stipulated regarding the qualities of absorption oil. Some operators have gone to considerable effort in demanding an absorption oil that will not mulsify, show a small shrinkage when treated with sulphuric acid, have a high initial and low end point and be almost water white.

Realizing that all these qualifications were desirable and made more necessary perhaps because of the rapid deterioration of oil once it was put in the system, these operations were well justified in their demands for a clean high grade oil. All too soon this oil once in the system would become black in color, heavy in character, show a large acid shrinkage and leave a gummy tar residue when a sample was evaporated. It was a foregone conclusion that the oil would soon have to be completely drained and the system refilled with new oil.

This oil contamination may be the result of (1) particles of dirt and small globules of crude oil carried into the absorbers by the gas; (2) incorrectly designed direct fired preheaters; (3) oxidation of the oil by air brought in with the gas; (4) the concentration of the heavy absorption oil fractions by carrying away the light fractions in the gasoline.

Dirty absorption oils have the following effects on the operation of an absorption plant:

(1) Lowers the extraction efficiency in the absorbers because of its greater molecular weight; (2) any suspended particles or asphaltic residues in the oil are entirely inactive as absorbent media and their presence tends to lower the effective oil rate; (3) increases the water content of the lean oil, further reducing the effective oil circulation; (4) increases the heating and pumping costs due to decreased fluidity and higher specific gravity; (5) decreases heat exchanger efficiency by depositing gummy heat resisting films on exchanger surfaces; (6) increases pressure drop through equipment due to film deposit; (7) causes shut downs for cleaning equipment and changing oil; (8) loss of production due to shut downs. All of these factors tend to lower production and increase the cost per gallon of producing such gasoline.

CLEANING METHOD

Since the character of the accumulated foreign material in the system oil is such that filtering will remove only the solid suspended particles another method is necessary to employ in cleaning the oil. The most successful system so far uses a small auxiliary steam still to effectively remove the foreign material. To continuously reclaim the entire oil circulation would require large and expensive equipment. It has been found by experience that a sufficient portion of the circulated oil can be continuously cleaned to keep the lean oil remarkably free from undesirable material.

Such a system has been developed by the writer. This system comprises:

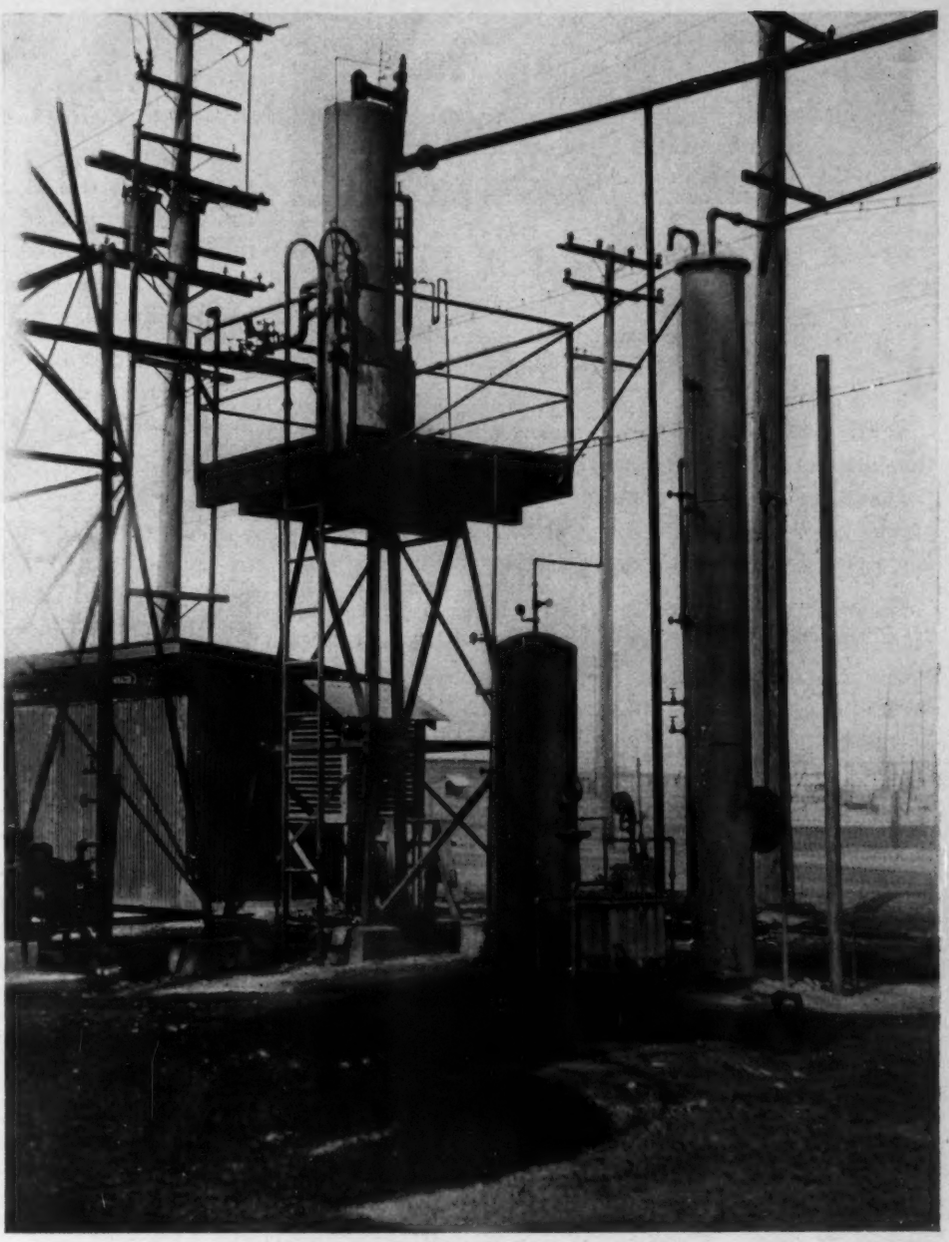
(1) A steam preheater for heating the feed; (2) a small steam still for purifying the oil, and (3) the necessary condensing and other small auxiliary equipment. A steam preheater is used because with the direct fired preheater on such a small amount of oil it is difficult to operate without burning the oil and cause larger amounts of oil residue than is the case with a steam preheater. The steam still is of special design and is the result of a large number of experiments. The outstanding features of this still as well as the process are its efficiency as an oil cleaner and its ease of operation. Once put in operation the unit requires practically no attention.

The amount of oil necessary to circulate through the reclaiming unit to keep the oil in excellent condition will

depend upon the degree of contamination and the rate of accumulation.

In a number of plants where this system has been installed the required continuous cleaning rate is less than 0.2 per cent of the main plant hourly oil circulation. During the initial cleaning period this rate may be increased to the maximum capacity of the unit. It has been found, however, that a treating rate of 1.0 per cent of the total oil rate will be sufficient to cleanse the oil in the system in about two weeks time. After this period the rate can be reduced to suit the circumstances.

The amount of residue oil drained from the reclaiming still will also depend upon the condition of the oil when reclamation is started and rate of accumulation of the foreign material. Experience has shown that the residue may be as high as 20 per cent of the treated oil at the start but will rapidly reduce and will finally amount to 2.0 to 3.0 per cent of the oil treated. Based on continuous operation following the initial cleaning period the residue loss should be only 2.0 per cent of 0.2 per cent of the hourly oil rate. Or in a plant circulating 100,000 gallons of lean oil per hour the loss would be 4.0 gallons per hour or 48 gallons per day, an insignificant quantity.



Absorption Oil Reclamation Still

The production gained by circulating a clean low molecular weight oil is proportional to the relative molecular weights of the oil before and after reclaiming, making the proper allowance for the suspended solid material in the dirty oil. Calculations show that a plant treating 10,000 mcf. of gas having a normal butane content of 0.65 G/mcf. will produce 400 gallons more gasoline per day with clean oil. In addition to this production gain, lower operating costs will result from the cleaner equipment and lighter oil, as pumping costs are directly proportional to pressure drop and the heating and cooling loads proportional to specific gravity of the circulated oil.

A typical oil reclaiming still installation is shown in the above picture. This unit is reclaiming oil in a plant of 150,000 gallons gasoline capacity, with an overall steam consumption of 18 boiler horsepower. This system is unique in its low operating cost, no pumps being required to handle the oil and its ease of operation. One of the most interesting features of this apparatus is the fact that once installed and kept in continuous operation the necessity of future oil changes is permanently eliminated.

This process and apparatus are being protected by patents, and arrangements will be made whereby these patents and the accumulated experience of Union Oil Company with this process will be made available to the industry.

EDITORIALS

PERUSAL of the price sheet has become almost a worship. In sales activity attention is centered first and last on price.

While prices control profit, their exclusive consideration prevents study of other factors also of prime importance. These other factors control prices; and they are to be weighed in advance of what money the finished product will bring in the market.

Rates of consumption, stocks on hand, and scale of manufacture are the factors which control price. If the time spent in mulling over the day-to-day changes in the price list were spent bringing the other three into harmony, prices would move into favorable relation to costs.

Another evil of this worship of the price sheet is that it confines the vision to a one-day horizon. Prices change daily and often several times in a day. So the man consumed by prices is not inclined to look beyond one day.

But the successful charting of policy requires that years rather than days be the measure of time. Consumption, stocks, and still throughput can be calculated by seasons or by years, if the vision has been raised to permit that scale of consideration.

These factors control price, so they must be charted if prices are to be altered. It is useless to strive to change a cause by wrestling with the effect. Alter causes and effects automatically change courses.

NO division of an industry ever had a remedy for its ills more clearly prescribed than did refining at the open meeting of the American Petroleum Institute at Chicago, November 10. The remedy was based on the contention that it is impossible to sell finished products at a profit when stocks are excessive. Numerous examples in other industries bear evidence of this contention. Refining itself has sufficient experience to accept the contention as true.

The remedy came in the presentation of figures which represent adequate stocks of finishd gasoline for the refining division of the petroleum industry. Two committees, each working separately, offered figures so nearly identical that they can be accepted as common working bases. The committee from the Federal Oil Conservation Board gave 45,000,000 barrels of gasoline April 1, 1931 as a recommended total, with 40,000,000 as a more desirable figure. The special committee named by the directors of the Institute recommended 40,000,000 as the maximum for April 1, 1931.

Study of the two reports leaves little doubt that the 40,000,000-barrel figure is a remedy for the ills of the refining division of the petroleum industry. Unfortunately legal obstacles made it impossible for concerted action to be taken on the two reports. But there is no barrier hindering individual acceptance and action.

If the refining division of the petroleum industry comes to April 1 with stocks in excess of 40,000,000, it is headed for a period of unprofitable prices. With stocks at or even slightly below that total, there is hope for a season of satisfactory returns on investment.

Plant operations so scaled to come to April 1 with not more than 40,000,000 barrels of gasoline, will add weight to the plight of the producing division of the industry. But the matter should be considered from the individual viewpoint of refining. Nothing the refining division does will greatly benefit the producing division, so the division of manufacturing will best serve the whole industry and especially itself by charting a course that promises profit.

To that end concerted action has gone its limit. Through the American Petroleum Institute the disease has been diagnosed and the remedy prescribed. Whether the refining division swallows its medicine or not is not a matter of decision with each unit of refining.

AFTER a year of predictions, it seems sensible to accept the conclusion that no man knows when business conditions over the world will improve. Certainly those who fixed certain months and seasons of the year for the upturn, have been wrong.

Now some of the more conservative of the economist clan have set the latter half of 1931 as the period that will show evidence of a favorable change. While they may be wrong, still there is soundness in their conclusions.

Another half year of sluggishness is not a welcome prospect. Still the economic structure of the United States has fared rather well considering the scope of depression in the year passed. Certainly it can weather another half year.

There is just one fact for the business man to keep before him — that business conditions will improve. Compared with 1930, there have been other years that were black beyond description. In each instance the wheels of business somehow gathered speed. They will do it again.

Business never knows when it is entering an economic hurricane. Neither does it seem to have the faculty for knowing when it is approaching calm sailing. Just as clouds gathered suddenly, so will the business skies clear suddenly.

Institute's Refining Sessions Growing in Importance

By GEORGE REID
Associate Editor

THE Division of Refining of the American Petroleum Institute at its sessions during the annual convention of the Institute at Chicago last month, earnestly attacked its technical engineering problems, characterized its discussions with a directness which added importance to its work, and with the best attendance yet seen at such sessions—brought much of its valuable technical information down to date to the end that these sessions of the refining group were the most valuable and informative that have been held under the guidance of the Institute.

With the decision of the board of directors of the Institute approving the plan of mid-year meetings of the three divisions of refining, production and marketing, opportunity is offered for furthering the work of the refining group and closer co-operation in the determination of best practices in the solution of the numerous operating and processing problems confronting the refining industry.

The division of refining, it was recently announced, now has a membership of 379 with indications that such membership will soon be much larger. With provision made for more frequent discussion of mutual problems, and for meeting places for the numerous committees of the division, greater interest in the activities of the division is sure to follow. With the continued development of technology and progressiveness of refinery engineering, and with the free and frank discussion of such problems as affect the industry in its economy and efficiency of operation, the work of the division of refining becomes of greater interest and importance, and of such importance that continued interest in its activities is assured and active membership, participating in the activities of the group, is almost essential.

The three technical sessions of the refining group were given over to the study of such problems as evaporation losses, reduction of fire hazards at refineries, the progress toward a uniform method of determining detonation, the mean of the gasoline distillation curve, color control of oils by acid treating, catalytic reactions of organic sulfur compounds and the hydrogenation of oils.

Drs. R. T. Haslam and R. P. Russell of Standard Development Company, stated that motor fuels of high anti-knock rating may be prepared from heavy petroleum stocks by hydrogenation, according to results obtained during recent investigations. The authors reviewed data previously presented before the American Chemical Society at Cincinnati and before the National Petroleum Association, Atlan-

Mid-Year Meetings

RECOMMENDATION of the American Petroleum Institute's divisions of refining, production and marketing that these units hold mid-year meetings at different times was acted upon favorably by the Institute's board of directors. Approval of this plan will be of great benefit to future annual meetings of the Institute, confining them to consideration of the board's general subjects of interest to the industry as a whole.

Under the mid-year meeting plan virtually all of the detail committee work will be removed from the annual program, including election of officers of the various divisional organizations, presentation of reports, and discussion of present and future activities. In this manner the congestion arising from the many committee meetings at the annual convention will be largely eliminated. With more than 70 committee meetings at Chicago this year it was possible to hold only two general sessions in which all those present could participate.

Divisions' members, meeting at different times and places will be able to give their full time to the discussion of subjects in which they are particularly interested, leaving only final reports to be presented at the annual gathering next year. This makes possible the further development of divisional activities on a larger scale and provides opportunity for the consideration of an ever-growing number of technical and engineering problems affecting the progress of the industry.

The time and place of the mid-year sessions are to be decided upon by the officers of the three divisions and be announced later. The annual meeting of the American Petroleum Institute will be held November 10, 11 and 12, 1931, at the Stevens Hotel, Chicago.

The mid-year meeting will be held at the Statler Hotel, St. Louis, April 15 *and* 16, 1931.

tic City, (see REFINER AND NATURAL GASOLINE MANUFACTURER, October, 1930, page 116). In addition they outlined the methods of preparation of hydrogen, and its purification, either from refinery or natural gas. In regard to the catalyst employed they stated that it is very rugged and largely impervious to sulfur poisoning, and that runs of eight months duration have been made with little apparent effect upon the catalyst. Through variations in the operating conditions high anti-knock gasolines may be produced, rating well above the present Ethyl gasoline standard.

FUNDAMENTAL research work in petroleum will be continued after this year as a result of the action of the board of directors at the eleventh annual meeting of the American Petroleum Institute. The directorate approved a plan for raising a special fund of $100,000 per year by contributions from individual companies with which the important and speedily progressing research work will be perpetuated.

The work of the fundamental research program was started nearly five years ago with a gift of $250,000 from John D. Rockefeller and a like contribution from Universal Oil Products Company; the period provided by these gifts expiring June 30, 1931.

The resolution favoring perpetuation of the research program was submitted by the committee on research of the American Petroleum Institute, consisting of Walter C. Teagle, W. R. Boyd, Henry M. Dawes, Henry L. Doherty, H. R. Gallagher, W. M. Irish, K. R. Kingsbury, J. Howard Pew, and Wallace E. Pratt.

COMBINATION REACTION

Such a reaction appears to be a combination of degradation and aggradation (up-grading) reactions, with the production of aromatic hydrocarbons controlled more or less definitely by the conditions under hydrogenation is accomplished. This type of synthesis is opposed directly to that in which lubricants are prepared or improved in which reaction saturation is increased to effect the production of compounds more paraffinic in nature. It differs also from the reaction in which the treatment of cracked distillates for the increased saturation of the lighter hydrocarbons effect a reduction of the amount of gum and other objectionable substances.

In answer to questions concerning what relation should exist between cracking and hydrogenation capacity and in regard to the fractionation of the refinery gases before they are used to manufacture hydrogen, Dr. Haslam stated "that the question of balancing the various facilities must be answered by local conditions but generally it is the belief that when cracking on a basis that produces 35 per cent of gasoline from the gas oil charged this would prove correct economically. Costs of power, oil, and other factors naturally exert an influence. If refinery gas is extremely heavy and loaded with naphtha fractions," Dr. Haslam stated, "it would be desirable to take those out of the way by fractionating. However, it is not necessary in most cases." He said also that to a certain degree the initial boiling point of the gasoline produced by hydrogenation must be controlled by the temperature of condensation of the fraction, just as is the case in other refining processes.

In answer to a question concerning what quantities of heat are involved in relation to the quantity of heat used in ordinary cracking processes, Dr. Haslam said:

"It is obvious that you are putting more heat into the hydrogenation process as power, but in regard to actual heat requirements I might say that due to the fact that we have no coke in the system, the actual used is something like 85 per cent regenerated and only 15 per cent put in as fuel."

In answer to a question having to do with the increasing of solid paraffin to effect a rise in the pour-point of the lubricants made by hydrogenation, Dr. Haslam stated:

"In general this is right, for the pour-point increases. That is due to two factors, that is, the oil is made more paraffinic and as you make oil more paraffinic there is a tendency not only in hydrogenation, but in nature, to make more paraffin. We also know that the pour-point of a low colored stock is usually below that of a light colored stock. The colors of all of the oils made by hydrogenation are between eight and 12 Robinson."

MEASURING DETONATION

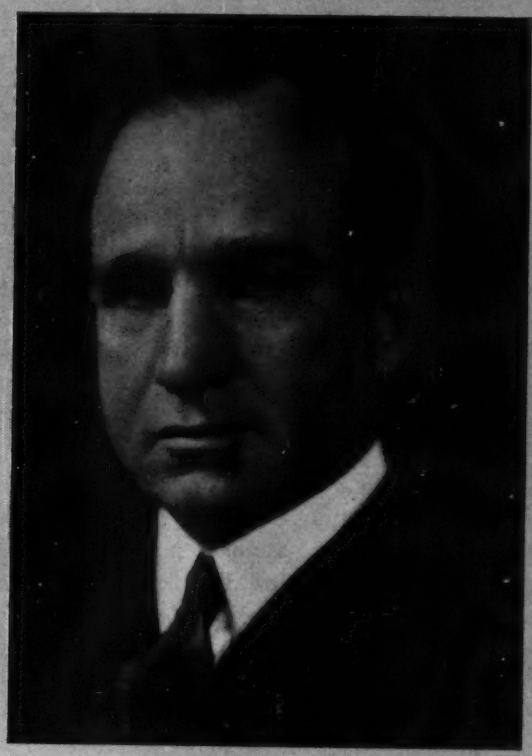
In his paper, "Progress Toward a Uniform Method of Measuring Detonation" (see REFINER AND NATURAL GASOLINE MANUFACTURER, issue of November, 1930, page 137), Dr. T. A. Boyd, who reported progress of the sub-committee on methods of measuring detonation of the cooperative fuel research steering committee, stated that much real progress has been made toward the desired standard. Engine details have been practically completed, a mixture of normal heptane and iso-octane has been tentatively decided upon as a standard reference fuel, and the major details of the method of operation and procedure are fairly well worked out.

Doctor Graham Edgar of the Ethyl Gasoline Corporation in his discussion of detonation measurement methods after the reading of the committee report told of the difficulties arising with regard to the preparation of a standard reference fuel, and of arrangements which have been made to provide an adequate supply for the next several years. He discussed the use of the normal heptane and iso-octane as reference fuels in this country and unofficially in England, stating that they must be secured in a very high and constant state of purity. The standard fuel is prepared by mixing various proportions of normal heptane with iso-octane until the detonation of the fuel prepared by this mixing is identical with the detonation of the fuel being tested. The rating of the test fuel then is expressed as the percentage of iso-

A. P. I. REFINING DIVISION

OFFICERS NAMED AT ANNUAL MEETING,
CHICAGO, NOVEMBER 10-13, 1930

E. B. REESER
President



R. C. HOLMES
Chairman, Refining Division

W. R. BOYD
Executive Vice-President

R. P. ANDERSON
Secretary, Refining Division

octane in normal heptane required to match the knock performance of the tested fuel.

Iso-octane is easily securable through synthesis but the normal heptane has been difficult to isolate. Dr. Edgar told of the occurance of iso-octane in the oleoresin or sap of the Jeffrey pine which grows almost exclusively in the high Sierras of California. The iso-octane may be recovered in absolute purity from the sap of this tree by a simple process of distillation and fractionation. The trees grow above the snow line and it is difficult to secure the required 500 to 1000 gallons annually for testing purposes. California Chemical Company has, however, agreed to undertake the supplying of the required amount provided the industry is willing to defray the expense (between $10,000 and $15,000) of installing equipment and sending men into the forests to secure the sap. This program has been approved and the supply of reference fuel is taken care of for at least the next few years.

Following the report and discussion of progress in measurement of detonation Dr. D. P. Barnard, IV, Standard Oil Company (Indiana) and Dr. Daniel Roesch of Armour Institute of Technology, who has been cooperating in the investigation, demonstrated the use of the acoustimeter in the measurement of knock intensity in a motor. The acoustimeter consists essentially of a magnetophone which picks up the sound of the knock, transmits it through amplifier tubes after filtering and submits them to an indicating milliammeter.

The engine used in the demonstration was an early model of the A. P. I. anti-knock engine developed by the special committee during the past three years. It was one of the first C. F. R. engines built by Waukesha Motor Company, had been in operation at the Whiting, Indiana, plant for about 18 months and had seen about 3000 hours of service but shows no indications of deterioration. It was equipped with a small carburetor and for use of both fixed and movable head. The acoustimeter reading as indicated by a needle hand moving over a scale clearly indicated the intensity of the knock as this was varied by changes in spark position or through the introduction of various fuels. Dr. Roesch stated that the instrument shows great sensitivity toward small differences in sound or detonation and the results secured are reproducible with proper care in operation of the engine and test. By its use, the human element may be virtually removed. This instrument was originally developed by the Association of Outboard Motor Manufacturers for the purpose of studying exhaust noises developed by small motors.

A group of English technologists consisting of Dr. A. E. Dunstan, chief technologist for Anglo-Persian Oil Company, Dr. F. H. Garner of Anglo-American Oil Company, and J. Kewley of Asiatic Petroleum Company, are cooperating with the American committee in this work of knock measurement. Such cooperation may result in the adoption of a universal method for determination of detonation.

FLUE GASES SAFE

The adaptability of flue gases in fire prevention and purification work was presented in two papers. H. H. Hall, Standard Oil Company of California, gave the details of his company's method of protecting oil tanks with this inert gas. A. E. Pew, Jr., Sun Oil Company, discussed the methods used by his company in both protection of tankers and the use of flue gases for sweetening or purification of refinery tanks, gas holders, fractionating columns, stills and the like. At the Marcus Hook, Pennsylvania, refinery of Sun Oil Company, where this method was developed, the flue gas is generated in individual units and blown through the tank, distillation unit, gas holder or other equipment where explosive mixtures may form. This blast of flue gas sweeps the equipment clean of hydrocarbon vapors. According to the writer the most effective of the three general methods for combatting fire hazards is the generation of flue gas for diluting hydrocarbon vapors below the explosive mixture percentage. The individual generators may be erected at a cost of around $1500 each and may be placed about the refinery yard adjacent to the equipment which they are used to purify, taking but little space. Their use effects a material reduction in volume of steam used for purification purposes in the refinery.

Discussion following the presentation of these papers developed the fact that where tankers were equipped with the flue gas generators and where flue gas was used less corrosion has occurred. Mr. Hall stated that this was the case and that the problem was under investigation. Records over a period of two years clearly indicate lessened corrosion but it will be necessary to continue observation before any final statement can be prepared. A smaller and more compact unit, of necessity, is installed on tankers than is employed on the refinery yard. In the later adaptation of the system some excellent results have been secured. Mr. Pew's discussion of flue gas generators as applied to refinery operations is presented elsewhere in this issue.

EVAPORATION

Discussion following the presentation of the paper, "Determination of Evaporation Losses" by G. W. Chenicek and W. G. Whitman, Standard Oil Company (Indiana) (see REFINER AND NATURAL GASOLINE MANUFACTURER, issue of November, page 115), and in which a new method was outlined for determination of evaporation losses by vapor pressure changes, indicated that the accuracy of the new method was good and that the development of an accurate method was welcome by technologists. In answer to questions Dr. Whitman stated:

"Casinghead, or any gasoline with a vapor pressure higher than one atmosphere at our standard temperature of 75°F. can be run at lower temperatures." As an example he cited instances where they carried out experiments at 45°F. for getting the vapor pressure of certain samples. The limit is determined on the

thermostat and its regulation. G. G. Oberfell of Phillips Petroleum Company then suggested that the Reid vapor pressure method could be used to secure similar results. Mr. Oberfell stated:

"I should like to suggest using the Reid vapor pressure apparatus itself. It may be used to determine losses in processing oils with vapor pressure of more than one atmosphere. The procedure would be to have several air bombs and measure the change in each vapor pressure as each succeeding bomb is added. In this case it would be necessary to have valves between each liquid bomb and air bomb, and to calculate the volume of vapors liberated."

Loss increases were reported in tanks that stand idle, but losses from standing tanks are lessened where the breather bag is employed. Losses during diplacement tests indicate greater evaporation losses in standard tanks than in floating roof tanks. The authors stated that the present accuracy of about 0.04 per cent is adequate for the detection of small losses, and is greater than would be required in many cases. Considering this accuracy and the wide field of applicability, it appears that the vapor pressure method discussed may be the most generally satisfactory means at present available for studying evaporation losses.

Knowledge of the lower part of the A. S. T. M. distillation curve is advancing most, but the problem of meeting changing weather conditions is still difficult of solution according to Dr. R. E. Wilson, who lead the discussion of a paper summing up the work of various agencies, "The Meaning of the Gasoline Distillation Curve" (see REFINER AND NATURAL GASOLINE MANUFACTURER, issue of November, 1930, page 129). In checking minimum and maximum temperatures in Minnesota, Dr. Wilson found a range of 4°F. to 103°F. in May or a change of 99 degrees, and in December a range from 70°F. to minus 57°F. which indicated a change of 127°F. He pointed out that with a fairly well designed fuel system and with gasoline having limited proportions of propane, a fairly wide temperature range exists at which starting is relatively easy and no vapor lock occurs.

Dr. G. G. Brown of the University of Michigan reported that it is virtually impossible to provide a gasoline which will give satisfactory starting at a temperature below minus 20°F. and not cause vapor lock at motor operating temperatures on cars as they are now designed.

Concerning the effect of the proposed Federal specifications for gasoline limiting the vapor pressure to 10 pounds Reid it was pointed out that the net effect is that with such limitations you can not get reasonably easy starting at temperatures below minus 10°F. To secure relatively easy starting gasoline can not be shipped that will start below 4°F. In the discussion of this condition Dr. Wilson stated:

"This is simply an outgrowth of unfortunate circumstances. The government needs to specify what it wishes to buy and to insure that the material is satisfactory for low temperature or high temperature operation, but U. S. motor gasoline specifications have been written into the laws of several states without regard to weather differences that may prevail and this can not be satisfactorily done. It seems to be that either the whole question of state legislation must be fought out in the proposition that a state has no power to forbid, and has no intention of forbidding, shipping of gasolines which start easy below 0°F.; or else that the Federal specifications must have a certain degree of flexibility, depending upon the average temperatures prevailing in the state into which it is shipped."

"Control of Color of Petroleum

Division Refining Personnel

Chairman, R. C. Holmes, The Texas Company, New York.

Vice-Chairman, W. R. Boyd, Jr., American Petroleum Institute, New York.

Secretary, R. P. Anderson, American Petroleum Institute, New York.

General Committee, elected by Membership.

Lloyd Bayer, Associated Oil Company, San Francisco.

Howard Bennette, Western Petroleum Refining Association, Tulsa.

C. B. Buerger, Gulf Refining Company, Pittsburgh.

E. M. Clark,* Standard Oil Development Company, New York.

O. L. Cordell, Phillips Petroleum Company, Tulsa.

L. R. Crawford,* Producers & Refiners Corporation, Independence, Kansas.

Fayette B. Dow, National Petroleum Association, Washington, D. C.

E. H. Eddleman, American Refining Properties, Wichita Falls.

John L. Gray,* Deep Rock Oil Corporation, Tulsa.

C. W. Hadley, Vacuum Oil Company, New York.

J. S. Harrison, Standard Oil Company of Ohio, Cleveland.

R. E. Humphreys, Standard Oil Company (Indiana), Chicago.

E. W. Isom,* Sinclair Refining Company, New York.

G. Legh Jones,* Shell Oil Company, San Francisco.

K. G. Mackenzie, The Texas Company, New York.

E. J. Marston, Texas Pacific Coal & Oil Company, Fort Worth.

Walter Miller, Continental Oil Company, Ponca City, Oklahoma.

W. L. Stewart, Jr.,* Union Oil Company, Los Angeles.

Chas. L. Suhr,* Pennzoil Oil Corporation, Oil City, Pennsylvania.

C. B. Watson,* Pure Oil Company, Chicago.

Appointed by President

W. M. Irish,* Atlantic Refining Company, Philadelphia.

K. R. Kingsbury,* Standard Oil Company of California, San Francisco.

C. F. Meyer, Standard Oil Company of New York, New York.

P. M. Miskell,* Empire Companies, Tulsa.

J. Howard Pew,* Sun Oil Company, Philadelphia.

***Re-elected.**

Oils by Acid Treating," by H. M. Weir, W. F. Houghton, and F. M. Majewski, Atlantic Refining Company, proved to be a very thorough study of acid treating problems. The complete paper is presented elsewhere in this issue of THE REFINER AND NATURAL GASOLINE MANUFACTURER. In the discussion following presentation of the paper, technologists were inclined to disagree with the authors concerning their statement that the results of their work make it difficult for them to believe that the reaction is largely one where sulfuric acid is a reactant. The loss of acid in the reaction is insufficient to sustain the chemical theory. The physical, or solution, theory of acid treating is well supported by experimental data. The authors state that it is planned to continue the work, part of which has already become routine in connection with their plant operations, in the hope and with the promise that much of the speculation and all of the lore can be removed from the art of acid treating.

Dr. Hugh S. Taylor, Princeton University, reporting on the progress of A. P. I. Research Project No. 40, in his paper "The Catalytic Reactions of Organic Sulphur Compounds," stated that the addition of hydrogen gas to the reaction mixture in the removal of pure sulfur compounds from naphtha solutions increases the percentage of sulfur removal when operating with a nickel catalyst. An iron catalyst is useful in sulfur removal but to a lesser degree than nickel. He found also that the first passage of the vapors over the catalyst is the most effective, and that successive passages show a decreasing efficiency. The complete paper is presented elsewhere in this issue of THE REFINER AND NATURAL GASOLINE MANUFACTURER.

Reeser Serving Third Term As Institute President

CHICAGO.—Edwin B. Reeser, president of the Barnsdall Corporation, and for the past two years, president of American Petroleum Institute, will for the third term lead the activities of the Institute by the unanimous vote of the board of directors.

Mr. Reeser had indicated his desire to pass the office along to others but the general feeling of the directors was that it would be ill-advised at this time to make any change in view of the "splendid manner in which Mr. Reeser had directed the affairs of the Institute during the past two hectic years in the oil industry."

L. P. St. Clair, Union Oil Company of California, was reelected vice-president at large, as was W. R. Boyd, executive vice-president, A. L. Beaty, treasurer and Lacy Walker, secretary and assistant treasurer.

New divisional vice-presidents were elected with Robert R. Penn, Penn Oil Company, Dallas, vice-president for production, R. C. Holmes, The Texas Company, New York, vice-president for refining and E. G. Seubert, Standard Oil Company (Indiana), Chicago, vice-president for marketing.

The divisional vice-presidents serve as exofficio chairmen of the general divisional committees with Executive Vice-President W. R. Boyd as exofficio vice-chairman while C. A. Young, R. P. Anderson and Paul Hadlick are secretaries respectively of the producing, refining and marketing divisions.

The following executive committee was elected: The president, vice-presidents, treasurer, last retired president (E. W. Clark, Union Oil Company of California, Los Angeles) and J. Howard Pew, Sun Oil Company, Philadelphia, W. C. Teagle, Standard Oil Company of New Jersey, New York; H. F. Sinclair, Sinclair Consolidated Oil Corporation, New York; F. A. Leovy, Gulf Oil Corporation, Pittsburgh; W. S. Fitzpatrick, Prairie Oil & Gas Company, Independence, and Herbert L. Pratt, Standard Oil Company of New York, New York. Robert R. Penn, Penn Oil Company, Dallas, and A. L. Beaty, New York, become directors through their election as officers.

New Directors

Chicago.—Directors to fill vacancies created by expiring terms, nominated by the board of councilors and elected by the American Petroleum Institute, are as follows:

Production Group:

PACIFIC COAST SECTION—R. A. Broomfield, L. P. St. Clair* and Oscar Sutro.*

CENTRAL UNITED STATES—W. S. Farish* and Axtel J. Byles.*

Manufacturing Group:

PACIFIC COAST SECTION—H. H. Gallagher.*

CENTRAL UNITED STATES—Roy B. Jones.*

EASTERN UNITED STATES—Frank X. Fretter, F. R. Nutty and W. E. Smith.*

Distribution Group:

PACIFIC COAST SECTION—K. R. Kingsbury.*

CENTRAL UNITED STATES—L. L. Marcell,* Henry M. Dawes and E. W. Sinclair.

Transportation Group:

SHIPS—J. Howard Pew.*

PIPE LINES—C. H. Kountz.*

Supply Group:

J. M. Crawford.

Foreign Trade Group:

Walter C. Teagle.*

At-Large Group:

C. B. Ames,* Jacob France, Wirt Franklin, S. A. Guiberson, W. F. Humphrey, D. J. Moran,* W. G. Skelly,* E. J. Bullock and R. W. Stewart.

Elected by the Board of Directors:

W. M. Keck, C. F. Myers, J. C. Van Eck* and George P. Whaley.*

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* Re-elected.

Catalytic Reactions of Organic Sulfur Compounds

By HUGH S. TAYLOR

A GENERAL survey of the problems of the reactivity of sulfur compounds present in petroleum when brought to reaction in presence of contact agents has been given. It has been shown that much can be predicated as to results from analogy with the known reactions of organic compounds of similar types, but containing oxygen or nitrogen in place of sulfur. The conclusions thus reached theoretically are substantially confirmed experimentally by work in progress on Project No. 40 of the American Petroleum Institute research program. The variations attributable to temperature, pressure, catalyst, and reacting gas are summarized; and the importance of the type of the sulfur compound treated, as determining the ease and extent of removal, is indicated.

This paper read before the Eleventh Annual Meeting of the Institute at Chicago, November 13, 1930, summarizes the results to date of an investigation on Specific Adsorbents of Sulfur Compounds in Petroleum, listed as Project No. 40 of American Petroleum Institute Research. Financial assistance in this work has been received from a research fund donated by John D. Rockefeller. This fund is being administered by the American Petroleum Institute with the cooperation of the Central Petroleum Committee of the National Research Council.

The author, Hugh S. Taylor, is Director, Project No. 40, Professor of Physical Chemistry, Princeton University, and Chairman of the Central Petroleum Committee, National Research Council.

SULFUR compounds in petroleum constitute at present one of the major problems of the petroleum industry alike in the producing, the refining, and the consuming branches of the business. The mounting production of higher sulfur crudes suggests that the importance of the problem may increase still further rather than diminish. There are various aspects to the problem involving, for example, corrosion both in production and consumption, which latter corrosion suggests the desirability of efforts for the elimination of the sulfur content of the petroleum during the refinery treatment.

The developments in refinery technique during the last decade or two have served to demonstrate the variety of behavior shown by sulfur compounds present in petroleum when subjected to various refinery methods of operation. It is well known how, in straight distillation of petroleum hydrocarbons, the successive fractions reveal each their quota of sulfur compounds present. It is known also that in the liquid-phase process of cracking, while modification of sulfur content does occur, much of the original content of sulfur is to be found in the lower-boiling distillates. The recent developments in vapor-phase cracking of petroleum suggest a striking divergence from the behavior in liquid-phase cracking in that claim is made that, in vapor-phase processes, the elimination of sulfur compounds as hydrogen sulfide attains major proportions. The same claim of a high degree of sulfur elimination is made in the newly developed method of treating liquid petroleum products at high pressures of hydrogen, with catalysts and under varying conditions of control, the process now known as oil hydrogenation.

It is striking that, in a field of this importance, the fundamental scientific data relative to the sulfur compounds in petroleum and their reactions are so very meager. The presence of certain types of sulfur compounds in petroleum sources and products is known, but knowledge of individual compounds present is almost entirely lacking. The number of carbon-sulfur compounds prepared, isolated, and defined in properties is small compared with the vast literature of carbon compounds in which oxygen, nitrogen, and hydrogen are the concurrent elements. The reactivity of such sulfur compounds under varied conditions of temperature, pressure, reaction, and contact agents is but scantily known even in the case of individual compounds, and much less so in the case of natural products which may contain such sulfur compounds in complex mixtures. This, therefore, constituted a field to which the attention of those responsible for fundamental research in connection with the American Petroleum Institute's program had inevitably to be directed. The present communication records some of the conclusions to which researches conducted under the above auspices are leading (Project No. 40, American Petroleum Institute research program), and outlines some of the directions in which the work is being extended.

It has already been noted that the sulfur compounds present in petroleum possess a degree of stability when subjected to conditions operative in straight petroleum distillation; but that in the altered conditions, mainly of high temperature, present in vapor-phase cracking, a marked conversion of sulfur compounds to hydrogen sulfide occurs. It is well known that appreciable reduction in reaction temperatures of many processes can be secured by the use of contact agents in a variety of chemical processes, the discovery and employment of

which agents constitute the field of so-called catalytic investigation. The addition and removal of hydrogen from chemical compounds, hydration and dehydration, processes of decomposition, condensation and polymerization are all processes for which catalysts have been found to secure the smoother and more efficient operation of the desired reaction at temperatures lower than this could be secured without the aid of such contact agents. How little attention has been paid to the corresponding reactions involving addition or removal of sulfur to or from organic compounds may be instanced by the fact that in the standard text of the subject (Sabatier-Reid, *Catalysis in Organic Chemistry*. D. VanNostrand Company) there are in the subject index only two references to the addition of sulfur and one to the removal of sulfur in a book of 350 pages and containing some 7000 entries in this same subject index. This observation demonstrates the lack of attention that has obtained with reference to this subject of essential importance today to the petroleum refiner.

The application of catalysts to the treatment of sulfur compounds has probably been delayed by the well known effect of sulfur compounds as poisons to catalysts being operated for the promotion of other reactions. Thus, for example, it is known that the presence of 0.01 per cent of sulfur compounds in a mixture of carbon monoxide and hydrogen will effectively destroy the activity of a nickel catalyst in the conversion of these reactants to methane. Similarly, the presence of traces of thiophene in benzene prevents the catalytic addition of hydrogen to benzene to form cyclohexane. It is probably from such experience that the impression has become general that sulfur compounds and active catalytic agents were incompatibles. A more extended acquaintance with the theory and technique of catalysis would show, however, that the problem is not so insuperable as might at first be believed. The examples of poisoning already cited are cases in which very efficient catalytic agents are required, in which only minute and localized areas of the catalyst are active in securing the hydrogenation process in question. With such processes the problem of poisons is acute. But there are a variety of catalyzed reactions, relatively easily accomplished, in which the presence of these same sulfur compounds is a matter of quite secondary import. Thus, it requires the presence of a very liberal amount of sulfur compounds to suppress the reduction of nitrobenzene by hydrogen in the presence of catalytic nickel. Furthermore, it is known that, as the operating temperature is raised in a particular catalytic process, the relative importance of the poison becomes, in many cases, progressively less; so that quite frequently the accidental introduction of catalyst poison can be overcome by a moderate rise in operating temperature. It may be useful to point out at this juncture that a corresponding ameliorative effect can be secured by elevation of hydrogen pressure (in a catalytic hydrogenation) without change in temperature. These beneficial effects of temperature and pressure elevation are attributable to the increase which they effect in the available catalytic surface. At the higher temperature a greater fraction of the total surface is capable of effecting the reaction in question. At elevated pressures, if the poisoning is reversible, the extra partial pressure of the hydrogen involves that a greater fraction of the total reacting surface is free from poison. Thus, water vapor is a reversible poison for iron in the synthesis of ammonia by reason of the formation of an oxide film on the surface. With a given ratio of hydrogen to water vapor, the surface attains an equilibrium expressible by an equation:

$$Fe_xO_y + yH_2 = xFe + yH_2O$$

It is evident that an increase in hydrogen-water ratio by increase of hydrogen pressure will operate in favor of an increase of available catalytic iron surface with a given partial pressure of water vapor. Transposing this to the case of hydrogen sulfide as a poison to nickel, it is evident that, with a constant concentration of sulfur compound (determined, for example, by the sulfur content of an oil to be hydrogenated), the availability of active metal in a nickel surface will increase with increasing hydrogen pressure by reason of the operation of the surface equilibrium:

$$NiS + H_2 = Ni + H_2S$$

For this reason it is only a logical deduction from well known chemical principles that the utilization of higher pressures of hydrogen in the hydrogenation of coal, oil, and other substances will *tend* to minimize the troublesome problems of sulfur poisoning. It is to the operation of this influence that the success reported in the treatment of high sulfur oils and coals in processes of high pressure hydrogenation is to be attributed.

The paucity of data relative to the reactions and behavior of sulfur compounds in the presence of contact agents requires that in the preliminary analysis of the problem reliance be placed on analogous reactions with compounds of similar types but containing other elements than sulfur. Thus, while data for the mercaptans, thio-alcohols, are conspicuously lacking, a wide variety of investigations deals with the reactions of alcohols. While little is known concerning the sulfides, much has been learned concerning the ethers, the oxygen analogs. While the poisoning action and resistance of thiophene to decomposition constitute our principal knowledge of cyclic sulfur compounds in presence of contact agents, much is known concerning the contact actions to be secured with cyclic nitrogen compounds such as pyridine, pyrrol, and the like. It is the reactions of these analogous compounds which must form the starting point for any scientific attack on the problem of contact reactions of the sulfur-containing compounds. And the outlook from such a survey is distinctly encouraging.

The alcohols undergo two well known types of de-

composition, dehydrogenation and dehydration, which may be represented by the generalized equation:

$$C_nH_{2n+1}OH \rightarrow C_nH_{2n}O + H_2$$
Aldehyde

$$C_nH_{2n+1}OH \rightarrow C_nH_{2n} + H_2O$$
Hydrocarbon

The former reaction is secured at a variety of metallic surfaces and also at the surface of a limited number of metallic oxides, such, for example, as zinc, manganese, and magnesium oxides. The latter process of dehydration is secured at various well known oxide surfaces such as those of silica, alumina, and thoria. The activity of these compounds in accelerating such reactions has been associated with their specific activity toward hydrogen and water respectively. Hence, by analogy, one might expect similar reactions with respect to the mercaptans:

$$C_nH_{2n+1}SH \rightarrow C_nH_{2n}S + H_2$$
$$C H_{2n+1}SH \rightarrow C_nH_{2n} + H_2S$$

of which only the latter would be of interest for purposes of sulfur elimination. By analogy with the oxides useful in processes of dehydration one might expect activity in such a process from compounds of known specificity toward sulfur compounds. It is well known, though perhaps not realized in this regard, that certain classes of compounds are essentially specific toward carbon-sulfur compounds, as witness the employment of such sulfur compounds in processes of oil flotation for concentration of *sulfide* minerals. The correlation of these data at once suggests that the analog of oxides in dehydration processes should be sulfides in processes for the elimination of sulfur.

One further reaction of mercaptans might here be noted, its hydrogenation to yield saturated hydrocarbon and hydrogen sulfide:

$$C_nH_{2n+1}SH + H_2 \rightarrow C_nH_{2n+2} + H_2S$$

The analogous reaction with the alcohols is not readily accomplished, but the reaction of amines and hydrogen to yield ammonia and saturated hydrocarbon is readily secured in contact with metal catalysts. One might expect, therefore, the hydrogenation of mercaptans in presence of metal catalysts, the efficiency of the process being determined by the availability of the metal surface under the operating conditions. Here let it be once again emphasized that elevation of hydrogen pressure would tend to secure such an objective.

Passing to the sulfides, one may predict, by analogy with the ethers, that their decomposition according to the reaction:

$$(C_nH_{2n+1})_2S = 2C_nH_{2n+2} + H_2S$$

will occur on catalysts for the corresponding reaction of hydrogen sulfide elimination from mercaptans, but at higher temperatures and less efficiently. The dehydration of the ethers is achieved on alcohol dehydration catalysts, but at higher temperatures. The reaction of the sulfides with hydrogen:

$$(C_nH_{2n+1})_2S + 2H_2 \rightarrow 2C_nH_{2n+2} + H_2S$$

will, therefore, have a correspondingly greater relative importance than in the case of mercaptans.

The contact reactions of cyclic sulfur compounds, such as thiophanes and thiophenes, may be deduced from the reactions of analogous cyclic bodies such as the furfuranes, the pyrrols, pyrrolidines, and pyridine ring systems. In these cases the opening of the cyclic system and elimination of the oxygen or nitrogen content requires a higher catalytic activity of contact agent than with the open-chain compounds. Precisely in this field of cyclic sulfur-carbon compounds, then, may difficulty of sulfur elimination be anticipated.

That this elementary theoretical survey of the field of catalytic reactions of organic sulfur compounds conforms to reality in practical investigations is evident from the work that is being conducted under Project No. 40 of the American Petroleum Institute's funda-

TABLE 1
Properties of Naphthas Investigated

Property	Straight Run		Cracked
	1	2	3
Per cent sulfur (raw)	0.410	0.278	0.357
Per cent sulfur (NaOH washed)	0.352	0.261	0.320
Hydrogen sulfide and free sulfur per cent—			
After 3 months' standing	0.030	0.043	0.035
After 8 months' standing	0.050	....	....
Mercaptan sulfur per cent—			
1. Method of Faragher, Morrell, and Monroe	0.057	0.041	0.015
2. Application of method of Borgstrom and Reid	0.090	....	....
Doctor	Sour	Sour	Sour
Color	9 Saybolt	5 Saybolt	Yellow
Gravity A. P. I.	49.300	53.800	50.600
Assay distillation—			
Initial boiling point deg. C.	48	42	30
25 per cent over at—deg. C.	116	110	100
75 per cent over at—deg. C.	212	180	190
Final boiling deg. C.	299	268	234

mental research program. It is not intended here to give the detailed account of these researches with all the various experimental records. These will be found in a series of separate publications, the first two of which will appear in a forthcoming issue of *Industrial and Engineering Chemistry*. Here, rather, a resume of the results obtained will be presented, and an indication will be given of their importance as an outline survey of the whole field and as an index to the need for a vigorous development of this type of fundamental research.

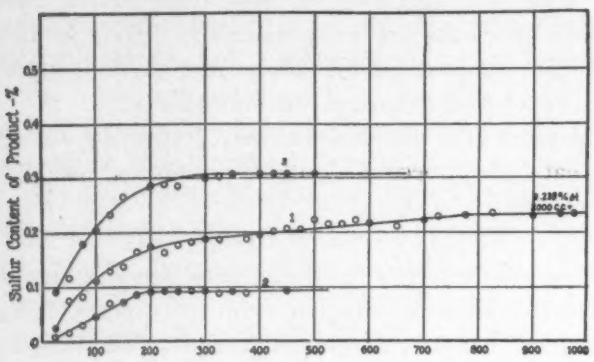

FIGURE 1

Removal of sulfur from naphthas in vapor form in contact with metallic nickel catalysts with no hydrogen added. Temperature, 300 deg. C. Curves 1, 2, and 3 show the results with naphthas 1, 2, and 3, respectively. The initial sulfur contents were 0.410 per cent, 0.278 per cent, and 0.357 per cent, respectively.

In the first communication concerning the work of Project No. 40, it will be demonstrated that metallic hydrogenation catalysts, such as reduced nickel and iron, exhibit a specific affinity for the sulfur compounds present in three typical high-sulfur naphthas, two straight-run and one cracked naphtha, containing respectively 0.410, 0.278 and 0.357 per cent sulfur. An extended investigation of the action of metallic nickel in removing sulfur compounds from naphthas in the form of vapor has been made. The experiments were carried out at 300 deg. and 400 deg., and at atmospheric pressure. They have been made with naphtha vapor alone and with the addition of hydrogen. The absorption of sulfur from the naphthas in the liquid phase has been determined, and the corresponding behavior of an iron catalyst, very active in the synthesis of ammonia, has been studied.

The naphthas studied, obtained through the courtesy of J. B. Hill of the Atlantic Refining Company, had the following properties.

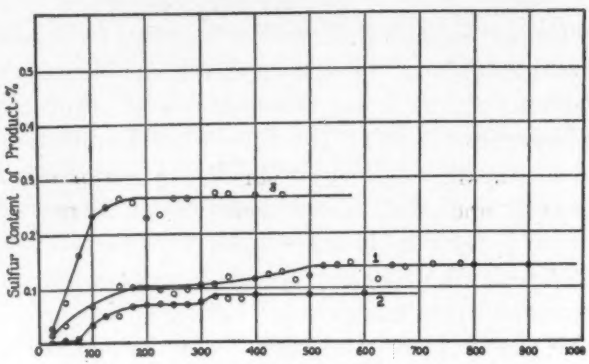

FIGURE 2

Removal of sulfur from naphthas in vapor phase by metallic nickel catalysts when hydrogen is added. Temperature, 300 deg. C. Curves 1, 2, and 3 are for naphthas 1, 2, and 3, respectively. The initial sulfur contents were 0.410 per cent, 0.278 per cent, and 0.357 per cent, respectively.

The curves of Figure 1 show typical results obtained when the naphthas studied were passed in vapor form over initially sulfur-free, active nickel catalysts at 300 deg. C. The sulfur content of each successive 25 cc. volume of the condensed product is plotted against the total volume of naphtha passed over the catalyst from the start of the run. The curves for the different naphthas possess the same general characteristics. After contact with the catalyst the first portions of naphtha contained extremely little sulfur. The sulfur content of the product first undergoes a rapid increase, then a slower rise to a point, which may be called the "steady state," after which no further change occurs. Thereafter the sulfur content is independent of the volume of naphtha which has been passed over the catalyst.

The amounts of sulfur removed from each naphtha at the steady state are recorded in Table 2 which also shows results obtained when hydrogen is passed con-

TABLE 2

Removal of Sulfur from Naphthas in Vapor at 300 Deg. C. at the Steady State by a Metallic Nickel Catalyst Which Was Initially Sulfur-free

		No Hydrogen Added				Hydrogen Added				
Naphtha	Original Sulfur Content Per Cent	Sulfur Content of Product Per Cent	Reduction	Per Cent of Sulfur Removal	Reaction to Doctor	Sulfur Content of Product Per Cent	Reduction	Per Cent of Sulfur Removed	Reaction to Doctor	Removal Due to Hydrogen
Straight Run										
1	0.410	0.22	0.190	46.3	Barely sour	0.14	0.270	65.9	Sweet	0.08
2	0.278	0.09	0.188	67.6	Sweet	0.08	0.198	71.2	Sweet	0.01
Cracked										
3	0.357	0.31	0.047	13.1	Sour	0.27	0.087	24.3	Sweet	0.04

TABLE 3
Action of Catalyst in Steady State in Removing Sulfur Under Various Conditions
Naphtha 1

Run No.	H_2	Temperature (Deg. C.)	Sulfur Content (Per Cent) Before Passage	Average After Passage	Number of Passages Over Catalyst
1	None	300	0.410	0.218	1
2	None	300	0.218	0.203	2
3	Added	300	0.229	0.220	2
4	Added	300	0.220	0.206	3
10	None	400	0.223	0.202	2 (first 2 passages
11	Added	400	0.202	0.149	3 without H_2
12	Added	400	0.410	0.213	1
13	Added	400	0.213	0.157	2
14	Added	400	0.157	0.133	3
15	Added	400	0.133	0.135	4

currently with the naphtha. It is evident, while the curves of Figure 1 are of the same form, quantitatively, the amounts of sulfur removed at each stage are dependent on the naphtha in question. The reduction in sulfur content depends upon the naphtha. The differences exhibited by different naphthas are undoubtedly due to variation in the nature and reactivity of the sulfur compounds present.

When hydrogen was not added to the naphtha vapor, no hydrogen sulfide was evolved until the steady state was approached. At the sharp bend in the curves of Figure 1 its evolution commenced. It then increased slowly, finally reaching a constant rate. It is evident that in the initial stages the sulfur is being retained by the nickel catalyst. At the steady state there is presumably a definite relation of sulfide to free nickel surface.

With hydrogen present (600 mm. naphtha vapor to 160 mm. hydrogen) similar data were obtained as shown in Figure 2 and summarized in Table 2. The

[1]The naphthas employed were from Cabin Creek crude and were supplied through the courtesy of C. R. Wagner of the Pure Oil Company

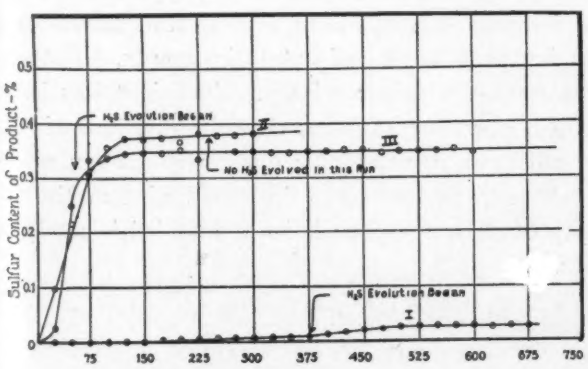

FIGURE 3

Effect of contact with initially sulfur-free nickel catalysts in vapor phase on sulfur content of naphtha containing butyl mercaptan or thiophene. Curve I: naphtha solution of butyl mercaptan, initial sulfur content of 0.375 per cent. Curve II: naphtha solution of thiophene, initial sulfur content of 0.388 per cent. Curve III: naphtha solution of thiophere, initial sulfur content of 0.388 per cent, hydrogen added. Temperature 300 deg. C. in each case.

characteristics of the curves and the divergencies of naphtha behavior are as found in absence of hydrogen, but the amounts of sulfur removed at each stage were increased. The increased removal due to hydrogen also varied with the sample. Hydrogen sulfide evolution occurred from almost the beginning of the run. It increased somewhat as the steady state was approached, and then remained constant.

Table 3 illustrates some data, obtained with a straight-run naphtha, concerning the effect of temperature on the process and also the effect of re-running a condensate. It will be noted that the first passage is relatively the most efficient, and that eventually further material reduction of sulfur content is not attained by re-passage under the given conditions. There is a small effect of temperature in increasing sulfur removal, and hydrogen increases removal of sulfur compounds not attacked in its absence.

The iron catalyst exhibits the same type of behavior as nickel, but is considerably less effective in its action than the latter. It reduced the sulfur content of naphtha 1 only to 0.338 per cent at the steady state in the one passage as compared with a reduction to 0.23 per cent with nickel.

That the differences in behavior with regard to sulfur removal encountered with the different naphthas are to be attributed to differences in the type and reactivity of the sulfur compounds present is evident from subsequent work. Pure sulfur compounds present individually in hydrocarbon materials have been studied in contact with nickel catalysts of the same type and activity as used in the work with the naphthas. Solutions of butyl mercaptan, isobutyl mercaptan, propyl sulfide, isopropyl sulfide, and thiophene in sulfur-free naphthas[1] were chosen for study. The catalyst employed had been brought to a steady state with butyl mercaptan. Typical data with and without hydrogen are presented in Table 4.

It is evident from the table that mercaptans and sulfides, but not thiophene, undergo a reaction evolving

TABLE 4

Removal of Sulfur from Naphtha Solutions of Individual Sulfur Compounds at 300 Deg. C. by a Nickel Catalyst in Steady State

Experiment No.	Sulfur Compound in Naphtha	Temperature (Deg. C.)	Rate of Flow (cc. liquid per hour)	H_2 Flow (cc. per minute)	Sulfur Content		Per Cent Reduction in Sulfur
					Initial	Final	
			No Added Hydrogen				
1	Butyl mercaptan	300	100	0	0.375	0.028	93
9	Butyl mercaptan	300	200	0	0.375	0.079	79
2	Propyl sulfide	300	100	0	0.393	0.309	21
3	*Iso*-butyl mercaptan	300	100	0	0.374	0.105	72
4	Thiophene	300	100	0	0.389	0.388	0
10	.*Iso*-butyl sulfide	300	100	0	0.388	0.323	17
				Added Hydrogen			
5	Thiophene	300	100	100	0.389	0.360	7.4
6	Thiophene	300	25	200	0.389	0.322	17.2
7	Thiophene	400	100	100	0.349	0.345	11.3
8	Propyl sulfide	300	100	100	0.393	0.137	65.1
11	Thiophene	300	100	100	0.388	0.350	9.8

hydrogen sulfide in contact with a catalyst in the presence of naphtha vapor. It is also apparent that the extent to which such reaction occurs and, consequently, the amount of sulfur removed depends upon the type of sulfur compound involved. Under the given conditions the mercaptans were removed more readily than the sulfides, and thiophene was not affected. It is probable also that the various members of each class of sulfur compounds will also differ in the same manner. The results in the second half of the table show definitely that the addition of hydrogen to the naphtha vapor effects partial removal of thiophene in contact with the catalyst at the steady state. Increasing the ratio of hydrogen to naphtha increases the amount of sulfur removed. The addition of hydrogen effects the removal of a strikingly larger proportion of propyl sulfide sulfur than is effected when no hydrogen is added.

The efficiency of other catalyst materials is now being tested at atmospheric pressure, principally with 0.5 per cent solutions of thiophene in benzene as involving the most resistant type of sulfur compound. Some results with a catalyst prepared from a mixture of molybdenum sulfide and cobalt oxide are shown in Table 5.

With contact agents from a, molybdenum sulfide; and b, molybednum oxide as starting materials, as much as 50 per cent removal of thiophene at 400 deg. C. and atmospheric pressure in hydrogen-benzene vapor streams has been secured. Preliminary work at higher pressures is in progress and more extended studies with other catalysts and sulfur compounds.

TABLE 5

Removal of Thiophene from Benzene

Catalyst Temperature (Degrees)	cc. Per Minute	Volume Ratio of H_2:C_6H_6	Per Cent of Thiophene Decomposed
305	50	100:85	24
353	40	100:60	36
405	40	100:60	44
352	95	100:25	22
403	95	100:15	26
450	95	100:25	42

The broad outlines of the problem are thus sketched in by the present data. Doubtless many of the details of the complete project are already to be found in the files of industrial-research organizations. Perhaps, too, the data should be supplemented by work on the interaction of sulfur compounds and steam in the presence of catalytic agents. That is, as yet, almost virgin territory. Sufficient has been indicated, however, to show that the problem of sulfur compounds in petroleum hydrocarbons can effectively be approached from the standpoint of the reactivity of such compounds in contact with catalytic agents.

Control of Color of Petroleum Oils by Acid Treating

H. M. WEIR, W. F. HOUGHTON AND F. M. MAJEWSKI
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IN order to control acid treating in the plant, a laboratory acid-treating procedure has been develop which is capable of operating under a variety of combinations. The method enables one quickly to determine for any oil the quantity and concentration of acid and the best conditions necessary for optimum color and oil yield. The samples employed are small, although large enough to allow further study on such details as bloom, color stability, gravity, viscosity, filter yield, etc. The results are reproducible and directly related to plant practice.

A complete study of the treatment of solar reduced stock, with acids of concentrations varying from 75 per cent to 98 per cent, was made which revealed interesting data on color removal, gravity, viscosity, index of refraction, oil loss, acid loss, and the heat of the acid-treating reaction. On the basis of the results of this investigation, some discussion of the generally accepted theories of acid treating is introduced.

This paper was presented at Eleventh Annual Meeting, American Petroleum Institute, Chicago, November 13, 1930.

DURING 1929 sulfuric acid worth more than $8,300,000 was applied to some 34,000,000 barrels of lubricating oil in the United States. The value of the acid recoverably lost in the treatment was in excess of $3,000,000, and the volume of lubricating distillate degraded to the value of fuel oil was probably not less than 3,000,000 barrels.

Though such figures promise financial savings which should amply repay fundamental study of the action of sulfuric acid on oils, it is a fact that very little literature has appeared which offers any basis for understanding what better acid treating is and how it may be accomplished.

No doubt the extreme complexity of heavy oil mixtures is responsible in large part for this situation, but tacit agreement on the part of many prospective workers with the old "axiom" that practical treating results cannot be obtained in laboratory apparatus has greatly hampered serious research work in the field. This paper presents a method of acid treating oils in the laboratory and of analyzing the results so that the conclusions can be directly applied to plant procedures without any factors other than the inefficiency of the latter.

It need hardly be mentioned that the first logical step in the improvement of a procedure is to measure its efficiency in terms of factors which bear a mathematical relationship to the effects produced. Finished lubricating oils are held to rigid specifications for gravity, viscosity, color, color stability, pour point, bloom, steam emulsion number, and acidity. The first three factors are capable of accurate measurement; the others are, in the present state of the art, highly artificial stipulations rather than determinations. Of the three factors which thus might offer a basis for study, the only one which seemed at the beginning of this work to stand in the relationship of cause and effect with respect to acid treating was the color of the oil.

On this basis alone, color was selected as the primary variable in studying acid-treating phenomena. Though it was felt highly desirable to retain as much standard practice as possible, the use of any standard color scale and coloimetric method was immediately ruled out. It seemed very unwise to attempt to clarify the relationships in an admittedly complicated series of reactions which hampered by units of measurements which, of themselves, bear no simple relationship one to the other.

The method of measuring and expressing the colors of oils which was selected is an adaptation of the system of measuring oil colors first published by Parsons and Wilson.[1] This system was first used by one of the authors in 1924 in unpublished work on the value of absorbents in "decolorizing" oils, work which paralleled to some extent the later work of Rodgers, Grimm, and Lemmon.[2] The interested reader may refer to these papers to obtain detailed information on this method of relating colors of oil. Discussion is purposely avoided here, since a paper will shortly appear from the laboratories of this company extending the accuracy of the method and pointing out certain conditions which must be met for most accurate results. It suffices to state that the system is based on a definition of color entirely similar to the concept of concentration of solutions. Thus a suitable oil is arbitrarily assigned a standard color figure, say 10. By definition the color which results by mixing S volume parts of the standard oil

with W volume parts of a white oil is taken as $\frac{S}{S+W}$. 10. The colorimetric scale and method are so arranged that this concept of color concentration is retained over the whole range of colors—from the darkest distillate to a white oil itself.

This color scale meets two requirements which are deemed absolutely fundamental: 1, a simple mathematical relationship between readings, as mentioned before; 2, the system makes it possible to assign color to the darkest distillate—a "black" oil in common parlance—in terms of the same units of color as those used to express the color of highly refined products.

The adoption of a simple and straightforward definition is, of course, no guarantee of simple physical relationships; but the character of the results which will be presented apparently justifies our original assumption that such would be the case. At all events, the ability to measure the color of very dark (dirty) oils gives a criterion of the quality of the raw material which apparently has not previously been used in studying acid treatment, despite the fact that it would appear to be fundamental to any serious study.

Colors taken on this scale were termed "true colors," abbreviated "t.c."; and a method of acid treatment was devised which uses the smallest possible amount of sample consistent with complete inspection of the product. A description of the treating procedure follows, together with typical results. Certain conclusions on the mechanism of acid treating are given and some speculations which we hope to explode or confirm in the future are also cited.

TREATING PROCEDURE

Before studying an untreated or reduced lubricating oil, its original color (true color), viscosity, and gravity are determined. The acid employed is measured from a 1 cc. or larger pipette directly into a graduated 100 cc. b. s. centrifuge tube containing 100 cc. of the oil to be treated. The acid falls through the oil and collects at the bottom as a light brown liquid, increased in volume approximately 10 per cent. The acid treatment is always carried out in duplicate.

After the addition of the acid, the tubes are closed with rubber stoppers and placed in groups of four in a mechanical shaking machine. The time of treating is measured from the start of shaking. In the shaker, illustrated in Figure 1, the tubes move about three inches backwards and forwards, 235 times per minute. When treatments at temperatures other than room temperature are made, the shaker is placed in a cabinet, the temperature of which can be controlled within 2°F. over the range of 80-170°F., and the oil is brought to the treating temperature before the acid is added.

The samples are shaken in the mechanical shaker until equilibrium is attained. The time for this varies, and must be ascertained for each type of oil. It is determined as follows: 0.5 cc. of acid is added to each of two tubes containing 100 cc. of the given oil, and 1.5 cc. each to two additional tubes containing 100 cc. of the same oil. The volumes 0.5 cc. and 1.5 cc. are, respectively, those quantities of acid which usually will under-treat and slightly over-treat the oil. For other oils, the quantities may be larger or smaller. The tubes are shaken for 10 minutes, centrifuged at 1,500 r.p.m. for one hour, and then examined for true color. In the same manner, the color is obtained on similar sets of tubes shaken for 25, 40, and 60 minutes, thus providing four points from which a color-shaking time curve for 0.5 cc. and 1.5 cc. of acid can be drawn. That shaking time which reasonably assures that the treatment has reached equilibrium or is at the optimum color is taken as the shaking time for all further tests. For viscous oils this may be from 20 to 40 minutes; while for naphtha-fluxed oils the optimum shaking time is usually 10 minutes.

Rather than wait for the sludge to settle out, the tube is centrifuged for 60 minutes at 1,500 r.p.m. It was found that centrifuging for at least 40 minutes was required to remove all of the fine pepper. Centrifuging at elevated temperatures was accomplished

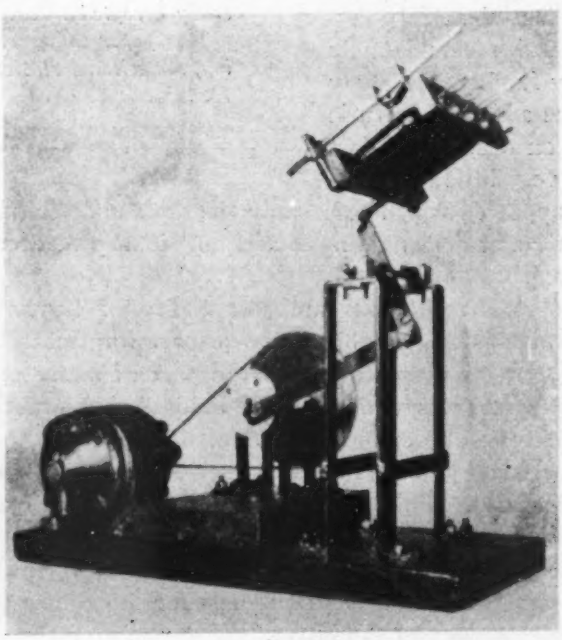

FIGURE 1

by passing burner gases at controlled temperatures around the jacketing framework of the centrifuge.

The oil colors were measured by means of the Duboscq colorimeter. The oil sample was diluted with a 50-50 mixture of white oil and extraction naphtha to a color of approximately 2½ N. P. A., and then compared with a 20 mm. depth of the standard oil (Manchester spindle). The average of six

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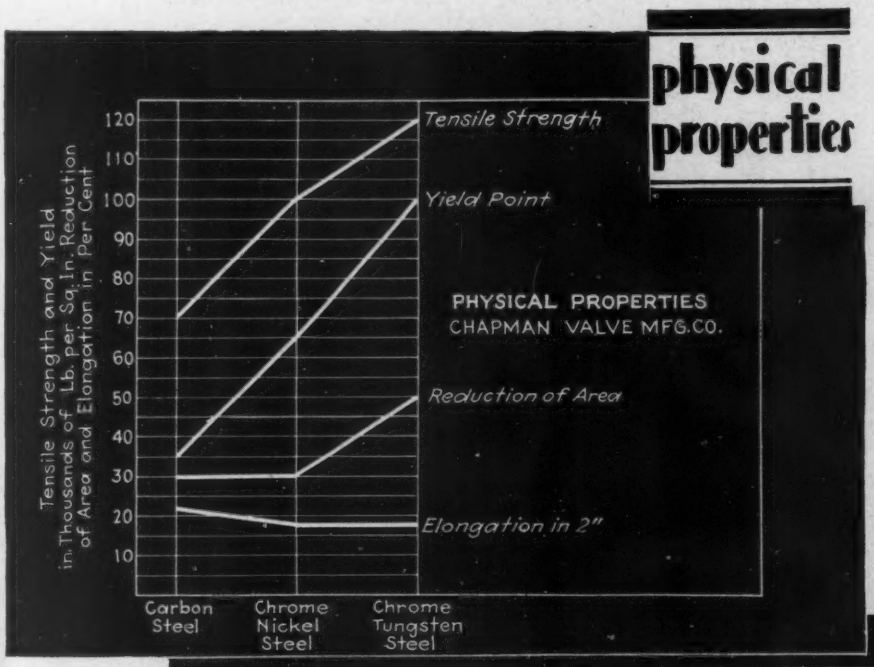

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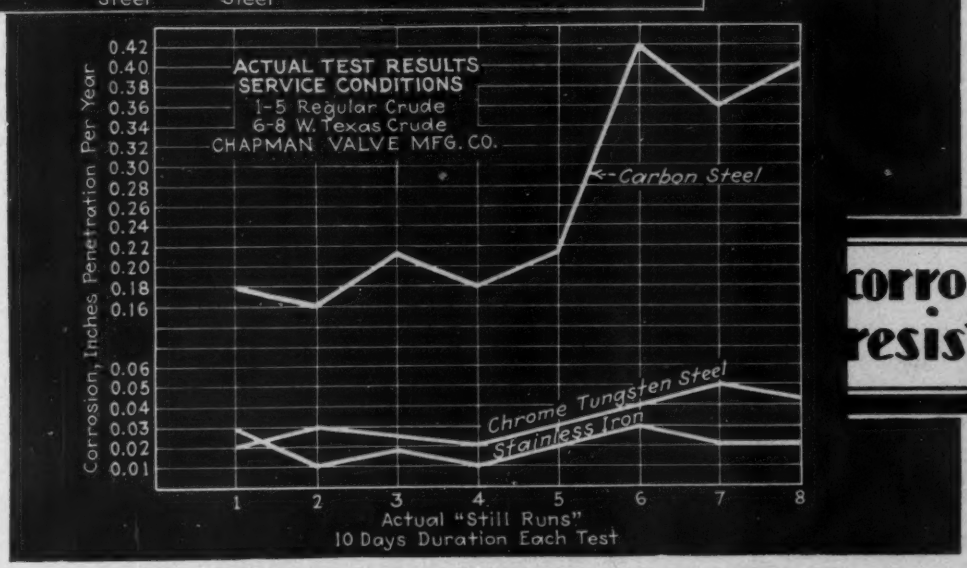

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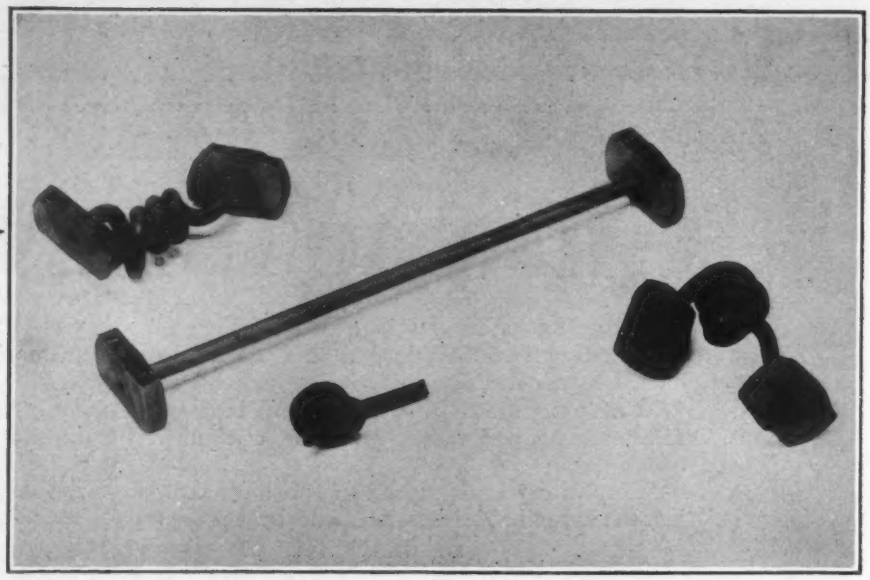

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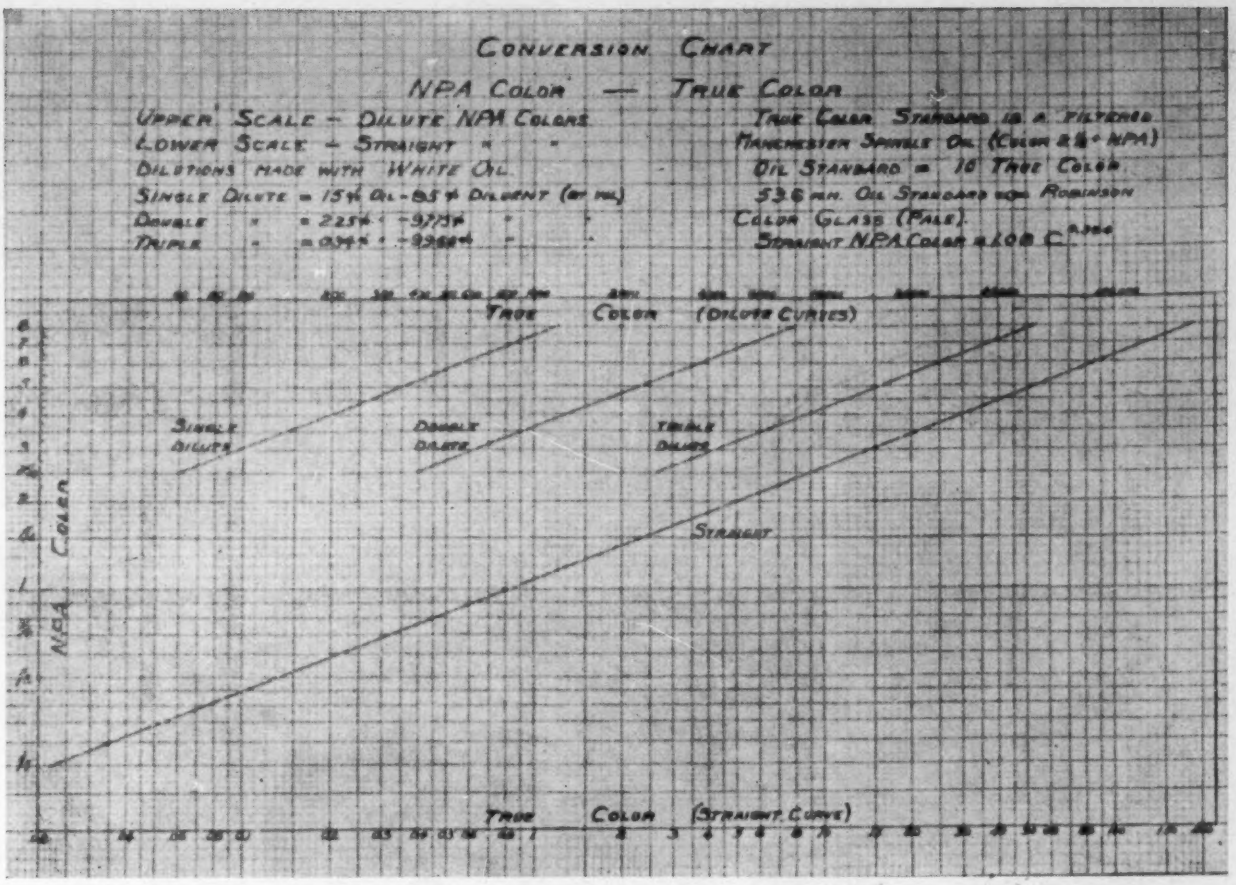
Conversion Chart
N.P.A. Color — True Color
Upper Scale = Dilute N.P.A. Colors
Lower Scale = Straight " "
Dilutions made with White Oil
Single Dilute = 15% Oil - 85% Diluent (by vol.)
Double " = 22.5% " - 97.5% " " "
Triple " = 03.4% " - 96.6% " " "
True Color Standard is a filtered Manchester Spindle Oil (Color 2.6 N.P.A.) Oil Standard = 10 True Color
53.6 mm. Oil Standard with Robinson Color Glass (Pale).
Straight N.P.A. Color at 100° C.
True Color (Dilute Curves)
Single Dilute
Double Dilute
Triple Dilute
Straight
N.P.A. Color
True Color (Straight Curve)

FIGURE 2

readings, read to within 0.1 mm., was taken as the final reading and the true color calculated by the following formula:

$$\text{True color} = \frac{20 \text{ mm.} \times \text{dilution}}{\text{average of 6 readings of unknown oil}} \times \text{true color of standard}$$

in which

$$\text{dilution} = \frac{\text{cc. of mixture}}{\text{cc. of unknown oil}}$$

Three types of colors were usually taken, the "sour oil" color, the "ammonia" color, and the "caustic neutralized and washed" color. The "sour oil" color was taken by the straight dilution of the sour oil; the "ammonia" color was taken after the oil had been saturated with anhydrous ammonia until no further change in color resulted; and the "caustic neutralized and washed" color was taken after neutralizing, washing, and brightening the sour oil at 150°F. Colors of duplicate samples usually checked within one true color unit.

A few additional facts concerning the true color scale should be mentioned. This scale is based upon a standard color oil, which in our case is filtered Manchester spindle oil of 2.6 N. P. A. color, and finally upon a Number 2 Robinson glass. The standard oil is calibrated in terms of the glass so much that when 53.6 mm. of the standard oil matches the Robinson glass the standard oil is said to have a true color of 10. The standard oil is rechecked every week; and, if it has become darker, proper allowance is made for this fact in subsequent determinations.

In measuring colors, the sample of the unknown oil is diluted so that its color approximates that of the standard. This has been found essential in order that the amount of light absorbed in the two cells may be equalized. The choice of diluent is likewise important in order to obtain truly additive colors. Naphtha or refined oil solutions of light and moderately dark oils are too dark, due possibly to the dissociation of the color bodies; while with still bottoms and other dark oils the colors are too light, due to the precipitation of the asphaltic constituents. Medicinal white oil solutions give colors which are additive, but the high cost and viscosity of the oil are disadvantageous. A mixture of equal parts of extraction naphtha and white oil has proven very satisfactory.

The comparison between true color and the N. P. A. color scale is illustrated in Figure 2.

STUDY TREATING

Solar reduced stock obtained from Seminole crude was chosen for the major part of the investigation of acid treating. Attention was concentrated on this stock for two reasons. First, it is a specific and recognizable cut among refiners; and, second, it forms the low viscosity oil base for the majority of the

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marketed motor oils. The stock had the following characteristics:

Viscosity at 80°F.	25.1 degrees A. P. I.
Gravity	790 seconds Saybolt
Viscosity at 100°F.	286 seconds Saybolt
Viscosity at 130°F.	129 seconds Saybolt
Pour	25 degrees F.
Flash	410 degrees F.
Fire	470 degrees F.
Water	Very slight trace
True Color*	112-140

*In the course of four months the stock changed from 112 to 140 true color. The assumption is made that the difference between the original color "bodies" and those which developed on standing is of second order in respect to the action of sulphuric acid in removing them.

The stock was treated according to the standard laboratory procedure, with 97.8, 93.2, 90.7, 86.0, 82.6 and 75.0 per cent sulfuric acid over the range of 0.05 cc. to 9.5 cc. of acid per 100 cc. of oil. The tests were

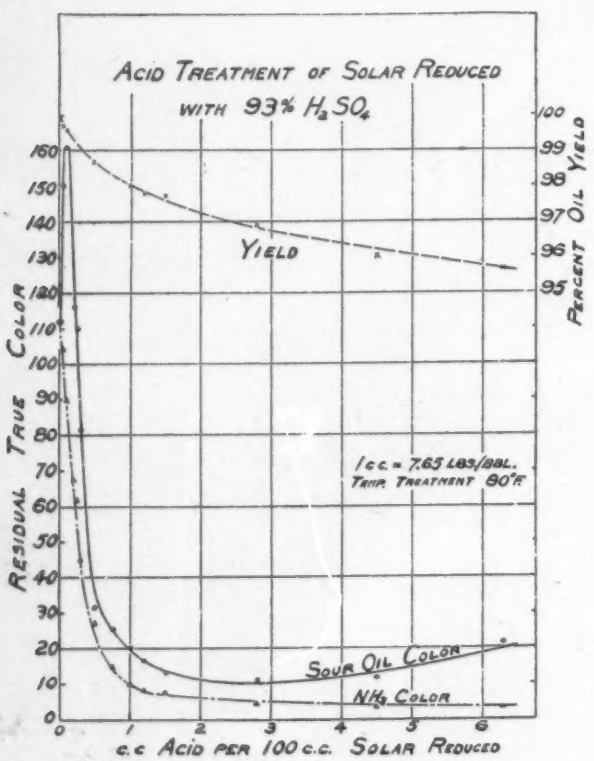

FIGURE 3

conducted at 80° F. ± 3°F., and the time of shaking was 40 minutes.

The effect of the volume of 93 per cent treating acid on the sour oil and ammonia colors is shown in Figure 3. It should be noted that the sour oil color curve passes through a maximum color of 0.1 per cent acid, which is 48 color units or 43 per cent darker than the original stock color. The sour oil color reaches a minimum true color of 11 (2.7 N. P. A.) at three per cent (23 pounds per barrel) acid by volume, and increases steadily thereafter to 26.5 true color at nine per cent acid. No such irregularities were observed in the ammonia colors of the treated oils. Here the acid functions immediately as a decolorizing agent, and a normal exponential curve is obtained.

The sour oil color curves obtained with the other concentrations of acid all show an initial increase in color, maximum at 0.1 per cent, but the degree of darkening apparently bears no relationship to the

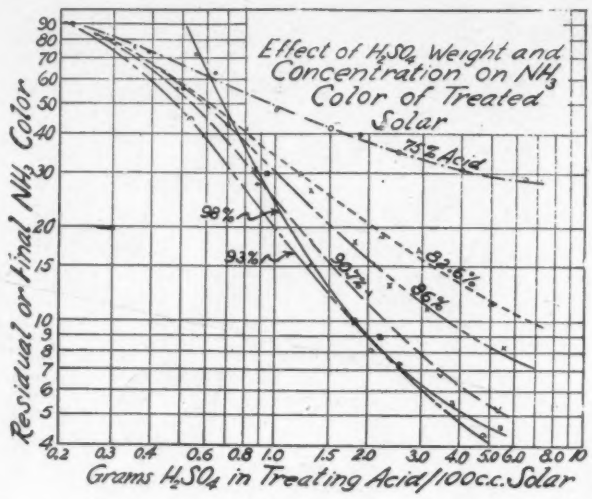

FIGURE 4

acid concentration. On the other hand, the darkening of the sour oil color due to excessive treating is greatest with 98 per cent acid and decreases regularly with diminishing concentration; 82.6 per cent acid darkens the color very slightly, and 75 per cent acid not at all.

The ammonia color, although a little light, resembles the caustic neutralized color much closer than does the sour oil. Where the sour oil is usually brown with a blue bloom, the ammonia color is a rich golden yellow, greatly improved in bloom.

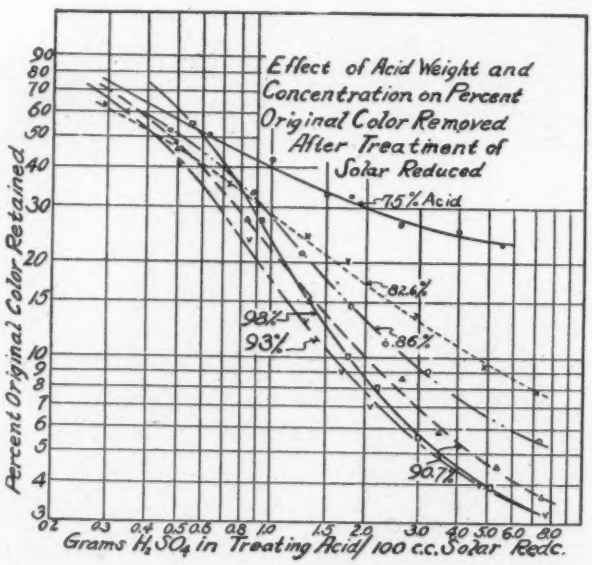

FIGURE 5

This change in color on neutralization with ammonia was found to be due to the presence of indicator-like bodies, for sour oils can be changed repeatedly from brown to yellow and back to brown by the alternate

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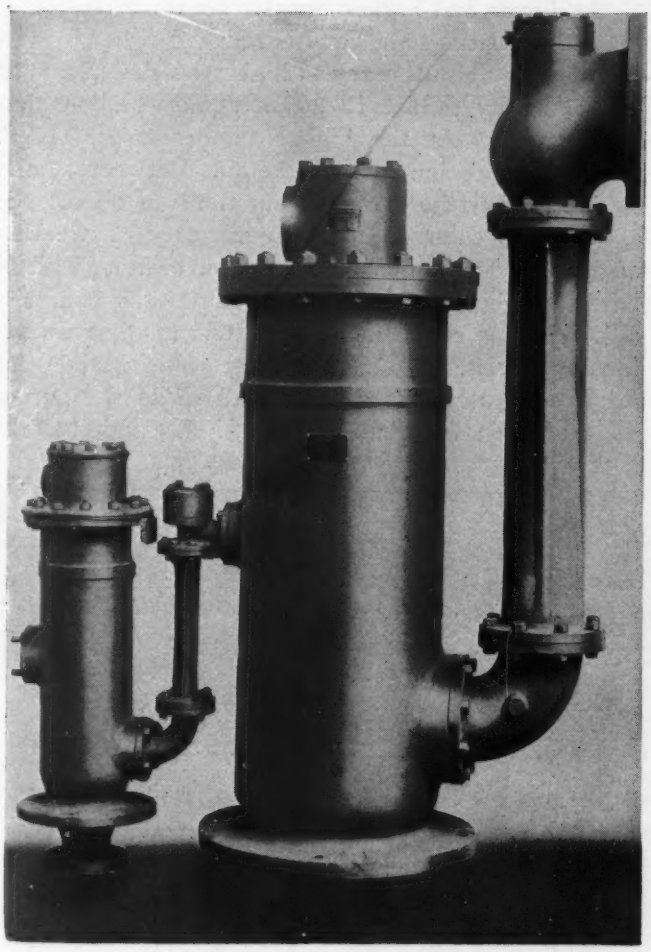

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addition of ammonia and hydrochloric acid. This effect is easily observed with dark naphtha-fluxed sour oils.

For the purpose of comparing the color-removing efficiencies of the six strengths of acid, the ammonia color was chosen as the basis for comparison, because it is more accurately defined than the sour oil

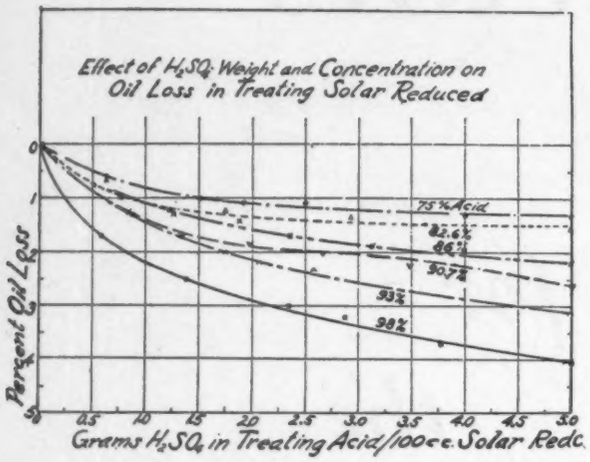

FIGURE 6

color and is closer to the plant caustic neutralized color. Figures 4 and 5 display on log paper this comparison, and show the final ammonia color and the per cent color removed as functions of the grams of sulfuric acid in the treating acid employed. The superiorities of 93 per cent acid are immediately apparent. Thus with two grams of sulfuric acid per 100 cc. of solar reduced stock (approximately 10 pounds, 93 per cent acid per 50 gallon barrel) colors ranging from nine to 38 true color are obtainable, depending on the acid concentration. For 15 true color, 1.3 grams of sulfuric acid are necessary when the treating is accomplished with 93 per cent acid. To obtain this same color with 98 per cent, 90.7 per cent, 86 per cent, and 82.6 per cent acid, 1.45, 1.7, 2.3 and 3.6 grams of sulfuric acid, respectively, are necessary.

It is important to appreciate that the inferiority of the weaker acids was far in excess of the molal equivalence of the highest concentrations of acid. The color removal is less a function of the weight of sulfuric acid involved than of the concentration of the acid. The color removed is also shown to bear no relationship to the oil loss incurred in treating.

It should not be understood, however, that 93 per cent acid is the most efficient acid for color removal in all cases. Fluxed bottoms are usually treated much more efficiently with 98 per cent acid. Also, in the case of the treatment of fluxed bottoms the caustic neutralized color is lighter than the ammonia color.

The effect of acid concentration on the sour oil loss is shown in Figure 6. This was determined by subtracting the acid volume from the total volume of the sludge at the bottom of the centrifuge tube. The stronger acids are far more drastic in their action on the oil than the weaker. As with color, the initial concentration of the acid, rather than the number of grams of sulfuric acid, is the factor which has greater influence on the yield.

TEMPERATURE

The effect of temperature on the treatment of solar reduced stock is not very pronounced, except at the lower and higher limits. At lower temperatures the treating efficiency is reduced either by virtue of poor agitation at the high viscosity (1,200 at 60°F.) or by failure to attain equilibrium at that temperature. At the higher temperatures, 140°F. or above, oxidation darkens the oil. Between 80 and 115°F. neither the ammonia nor the sour oil color is appreciably changed for any quantity of treating acid up to 15 pounds per 50-gallon barrel. This is borne out by Figure 7, which shows the complete acid treating curve for several temperature ranges for 93 per cent acid. Similar data were obtained for other concentrations of acid, and all of the curves were of the same general shape, indicating that the

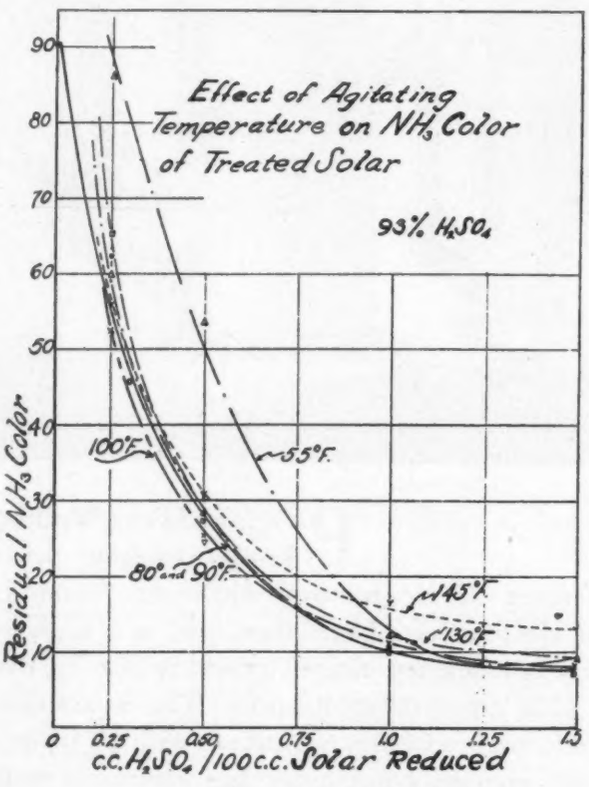

FIGURE 7

treating activity of a weak acid is specific and cannot be increased to equal that of a stronger acid by merely raising the treating temperature.

To determine whether acid is actually less efficient at low temperatures or whether the poorer results mean less effective contact due to high viscosity, a series of tests was made with fluxed solar reduced

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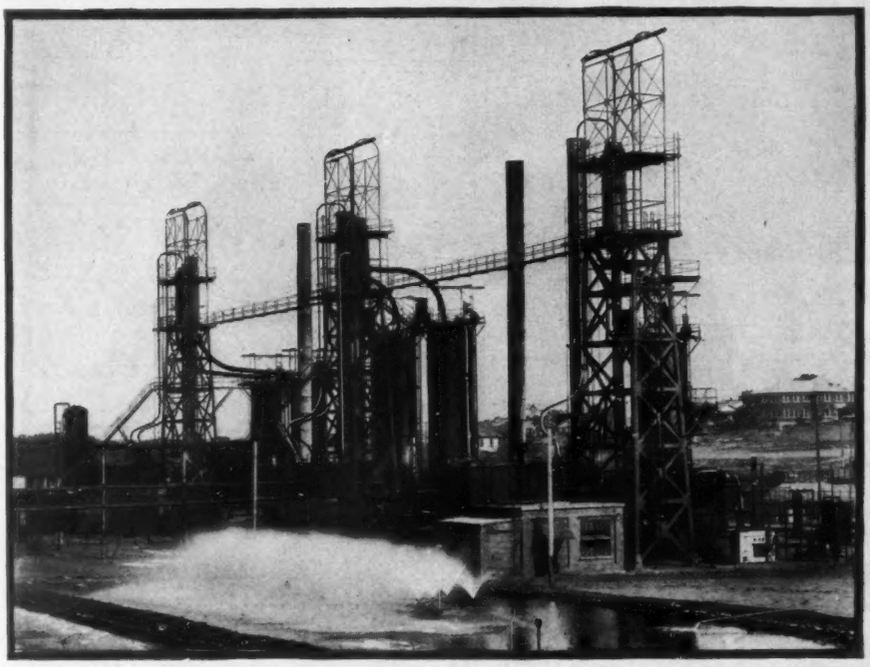

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stock over a temperature range from 32 to 147°F. The results indicate that color removal is improved at the lower temperatures when quantities of acid in excess of 1.5 per cent are employed. This is attributed to a decrease in oxidation. With less than 1.5 per cent acid, the color removal gradually becomes poorer as the temperature and the quantity of acid are decreased. Under these conditions, treating is impaired by virtue of the less fluid sludge. Treating

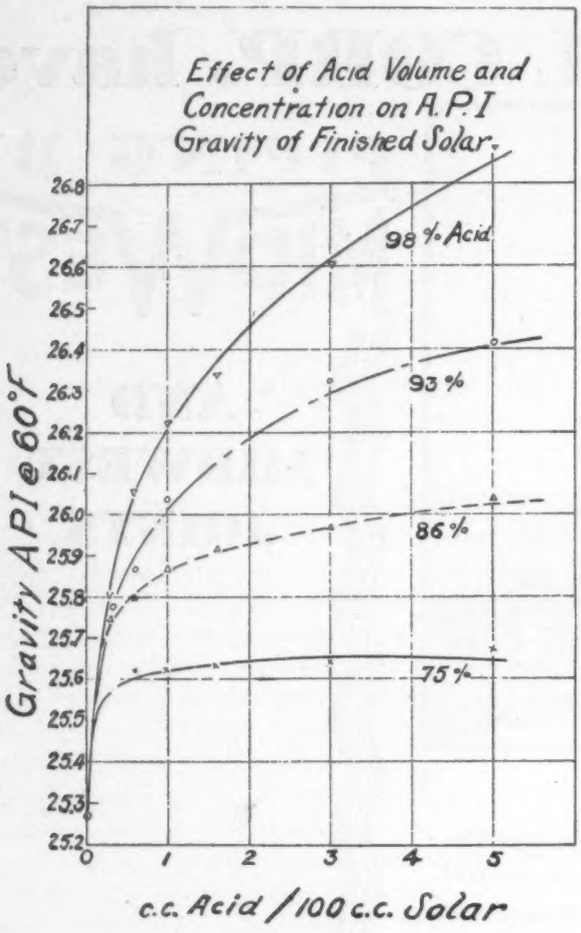


FIGURE 8

at high temperatures produces the opposite effect. Here the tendency is for the color to increase under all circumstances as the temperature and acid volume increase.

The treatment of naphtha solutions of bottoms and heavy oils is invariably improved by lower temperatures. This follows from the above discussion, as the acid volume in such cases is relatively large.

An important point to note is that the oil loss does not change with temperature, and is no greater at high than at moderate temperatures.

VISCOSITY, GRAVITY, AND INDEX OF REFRACTION OF TREATED OIL [2 4 5]

The specific gravities of the finished oils produced by treating solar reduced stock with various quantities and concentrations of acid were determined with a 10 cc. calibrated picnometer at room temperature and converted to A. P. I. gravity at 60°F. As shown in Figure 8, the first increment of acid produces a marked effect on the gravity. The A. P. I. gravity rises rapidly up to 0.6 per cent acid by volume. With greater volumes of acid, the increase is less pronounced. Stronger acids produce much greater changes in gravity than the weaker acids. This change is a function of the initial concentration of

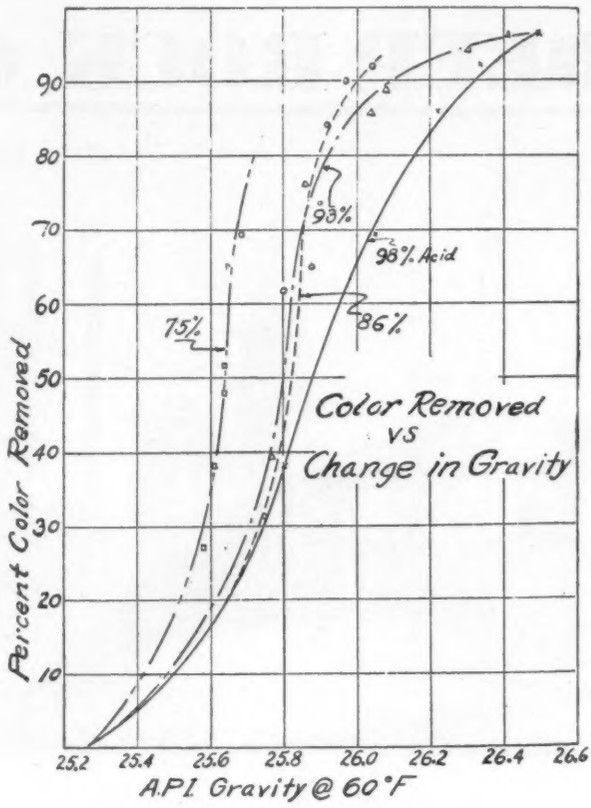


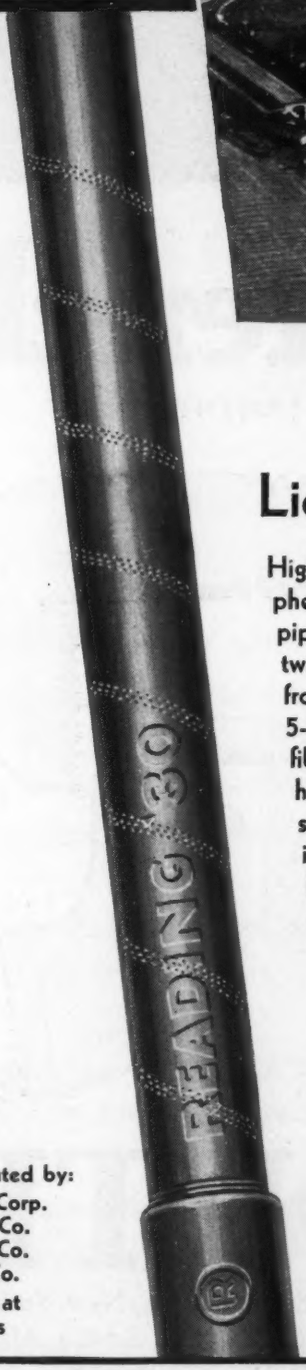
FIGURE 9

sulfuric acid in the treating acid rather than the grams of sulfuric acid employed. Such great changes in gravity can only be accounted for by the removal of very heavy bituminous bodies, and it seems doubtful whether mere polymerization of olefin bodies and their removal could have accomplished this change.

Color removal is not definitely related to the change in gravity (or removal of bituminous bodies); for where the greatest amount of color is removed per unit volume of acid the gravity changes but little (see Figure 9).

Oil loss is definitely related to the change in gravity by virtue of the fact that the gravity change is accomplished by the loss of high density substances from the oil. When the oil loss is plotted against the change in A. P. I. gravity (Figure 10), a straight line is obtained. These curves, however, do not exactly coincide for all acid concentrations, indicating that the material lost is not exactly the same for each acid.

The viscosities of the same finished oils were de-



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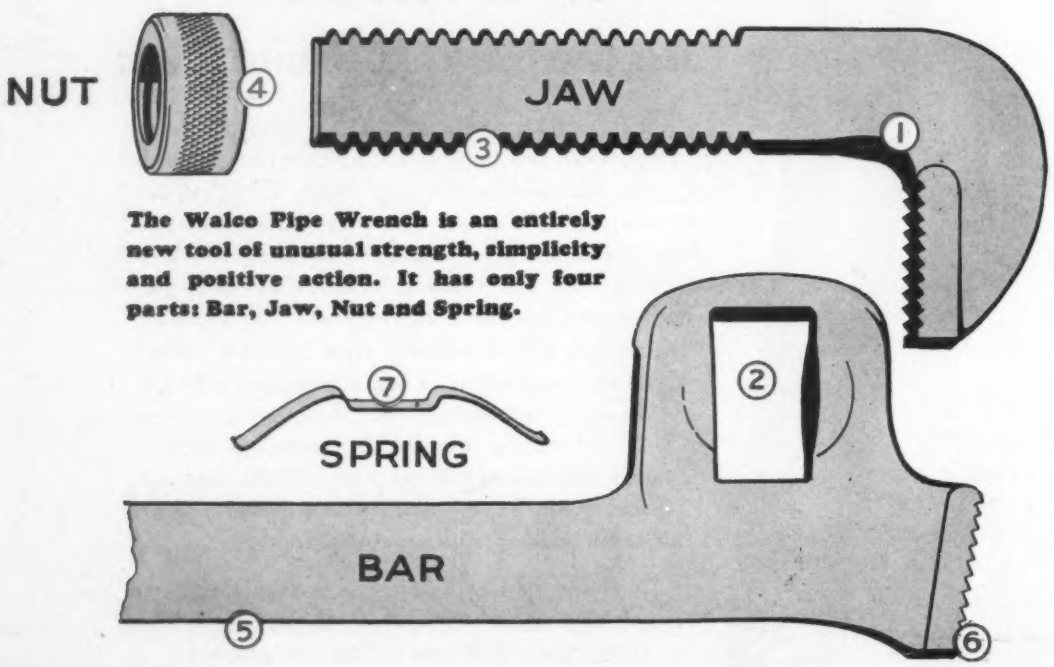

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termined in a pipette viscosimeter. Two determinations were made on each oil, and these were found to check within 0.1 seconds. The viscosity at 100°F. normally decreased as the concentration and quantity of acid increased. This is clearly shown in Figure 11, where the Saybolt viscosity at 100°F. is plotted against acid volume for 98, 93, 86 and 75 per cent acids. Solar reduced stock treated with 75 per cent acid represents an exception to the normal. With this acid, the viscosity first increases five seconds

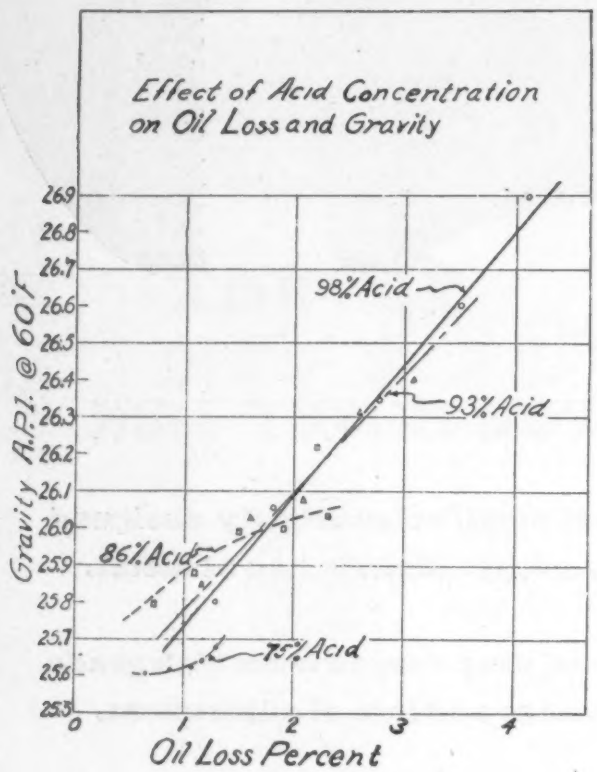

FIGURE 10

at 1.3 per cent acid by volume, and thereafter slowly decreases to two seconds below the initial viscosity as a limit.

The viscosity-gravity constant[6] of the treated oil likewise decreased as the concentration and quantity of acid increased, despite the decrease in viscosity. For normal treating conditions, the constant drops from 0.848 to 0.842. This corresponds to a small decrease in the naphthenic character of the oil.

The curve for the index of refraction of the finished oils resembles the density curve, in that the index decreases as the amount and concentration of acid increase, approaching values normally associated with paraffinic oils (Figure 12).

HEAT OF TREATING REACTION

The heat of the acid-treating reaction of solar reduced stock with various quantities and concentrations of acid was determined in an attempt to correlate color removal with heat of reaction.

The method consisted essentially in measuring the rise in temperature of the stock, previously brought to thermal equilibrium in a thermos bottle, after a definite quantity and concentration of acid had been added. Four hundred grams of oil was placed in a quart thermos bottle provided with a 100°F. viscosimeter thermometer readable to 0.05°F. The thermos bottle containing the oil was shaken in the mechanical shaker, and the temperatures read at intervals of 0, 2, 5, 9, 15, 20 and 25 minutes. The first reading was taken when the oil reached 94°F.; and after 25 minutes shaking, the temperature rose to 97.4°F. A definite quantity of acid at 98°F. was then quickly added and the shaking continued. Temperature readings were again taken at intervals of one, two, three, five, nine, 15, 20 and 25 minutes. The thermos bottle was placed in the shaker so that the thermometer was always immersed in the oil, and in taking temperature readings the shaker was stopped for from three to five seconds. More than 95 per cent of the temperature rise took place in the first minute.

The heat of reaction was calculated by obtaining the temperature rise by plotting temperature as a

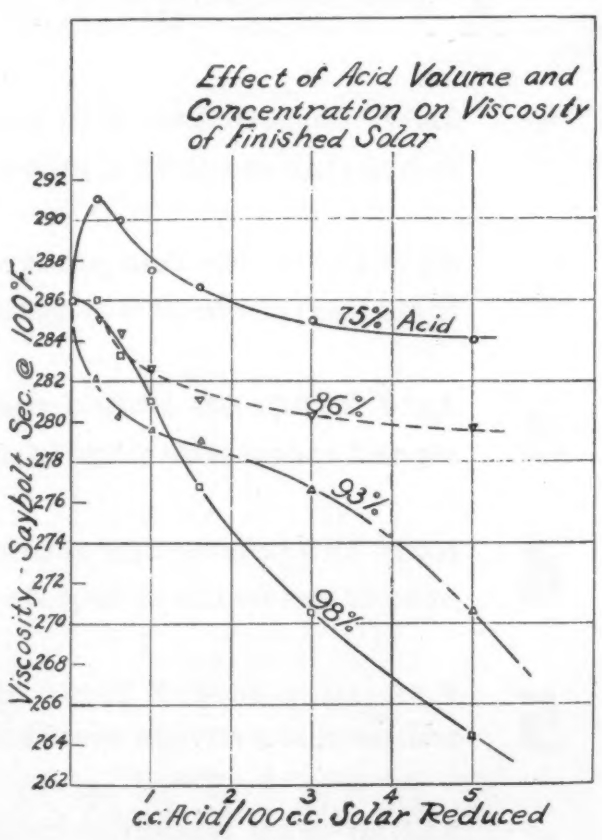

FIGURE 11

function of time, and correcting for the heat of mechanical agitation, the thermal equivalent of the apparatus, and the acid. Figure 13 summarises the results. It is apparent that the reactions with the various acids differ to a marked degree. When the same data are plotted as a function of color removal, the curves for 75 per cent, 86 per cent and 93 per

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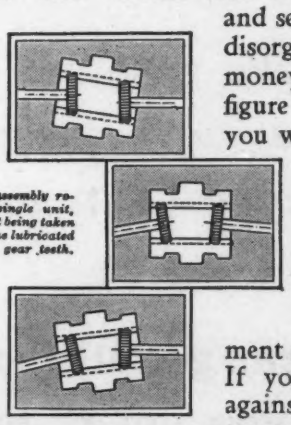

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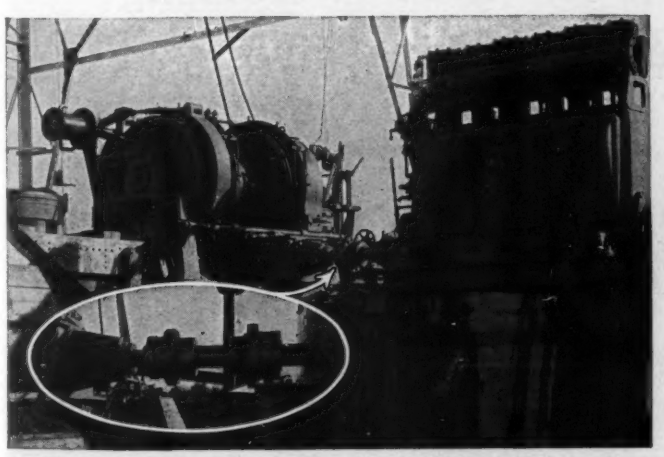

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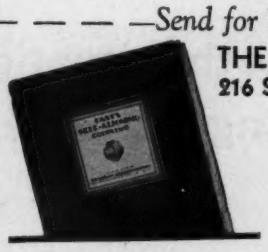

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cent acid almost coincide; while 98 per cent acid stands by itself, higher than the others because of secondary reactions. The extent of coincidence between these curves, however, is not sufficient to conclude that the heat of reaction is a direct function of the amounts of color removed. Moreover, the greatest quantity of heat was not liberated when the greatest amount of color was removed.

The heat of dilution of the treating acid undoubtedly plays a part in the total heat of reaction. Calculation based on the assumption that all of the heat was due to dilution showed that excessive dilutions were not required to produce the necessary heat, and it is quite possible that much of the heat may have arisen as a consequence of the dilution of the sulfuric acid by the water produced by the condensation of oxygen bodies.

The oil lost in the treating reaction is a straight

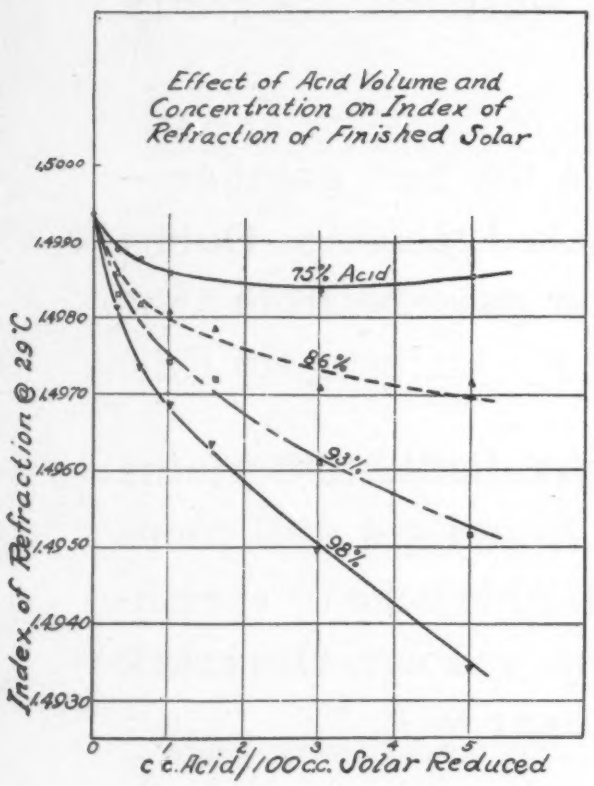

FIGURE 12

line function of the heat of the acid-treating reaction (Figure 14). This follows for all acid concentrations, and treatments having the same oil loss liberate the same amount of heat regardless of the treating-acid concentration.

ACID CONSUMED

Contrary to several statements in the literature, the actual acid consumed in treating is not very great. This applies in particular to solar reduced stock. Figure 15 shows the consumption of 93 per cent acid in the treatment of this stock.

In comparing the acid loss with the per cent color removed, we find that more than 92 per cent of the color is removed without an appreciable amount of acid loss (0.1 g. per 100 cc. oil). Further color removal can only be accomplished with a sacrifice of acid. The treating temperature was 95° F.

Part of this loss of sulfuric acid may be attributed to the formation of sulfur dioxide. A series of tests conducted at 95°F. along lines similar to the above showed this to be almost negligible. The per cent

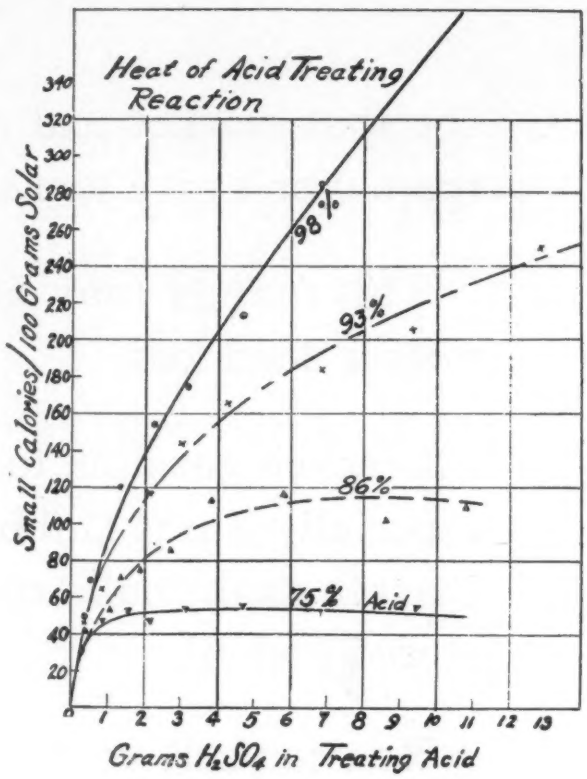

FIGURE 13

sulfuric acid by weight lost as sulfur dioxide varied from 0.06 per cent to 0.22 per cent for tests with 0.25 per cent to five per cent acid by volume. Ninety-eight per cent acid produced the greatest amount of sulfur dioxide.

These data were obtained by extracting the acid from the peppered oil with the aid of alcohol, benzene, and water. Five extractions usually reduced the acidity to 0.1 per cent of what it had originally been. The inherent error in the procedure was determined by blanks, and the results corrected correspondingly. Quantitative technique and apparatus were employed throughout.

THEORY OF TREATMENT

Practically all of the data presented so far have referred to the effect of sulfuric acid applied to solar reduced stock. A considerable quantity of data has been obtained in these laboratories on heavier oils in solutions. The results in general were parallel to those already cited, and justify in our opinion, such conclusions as have already been drawn. In what

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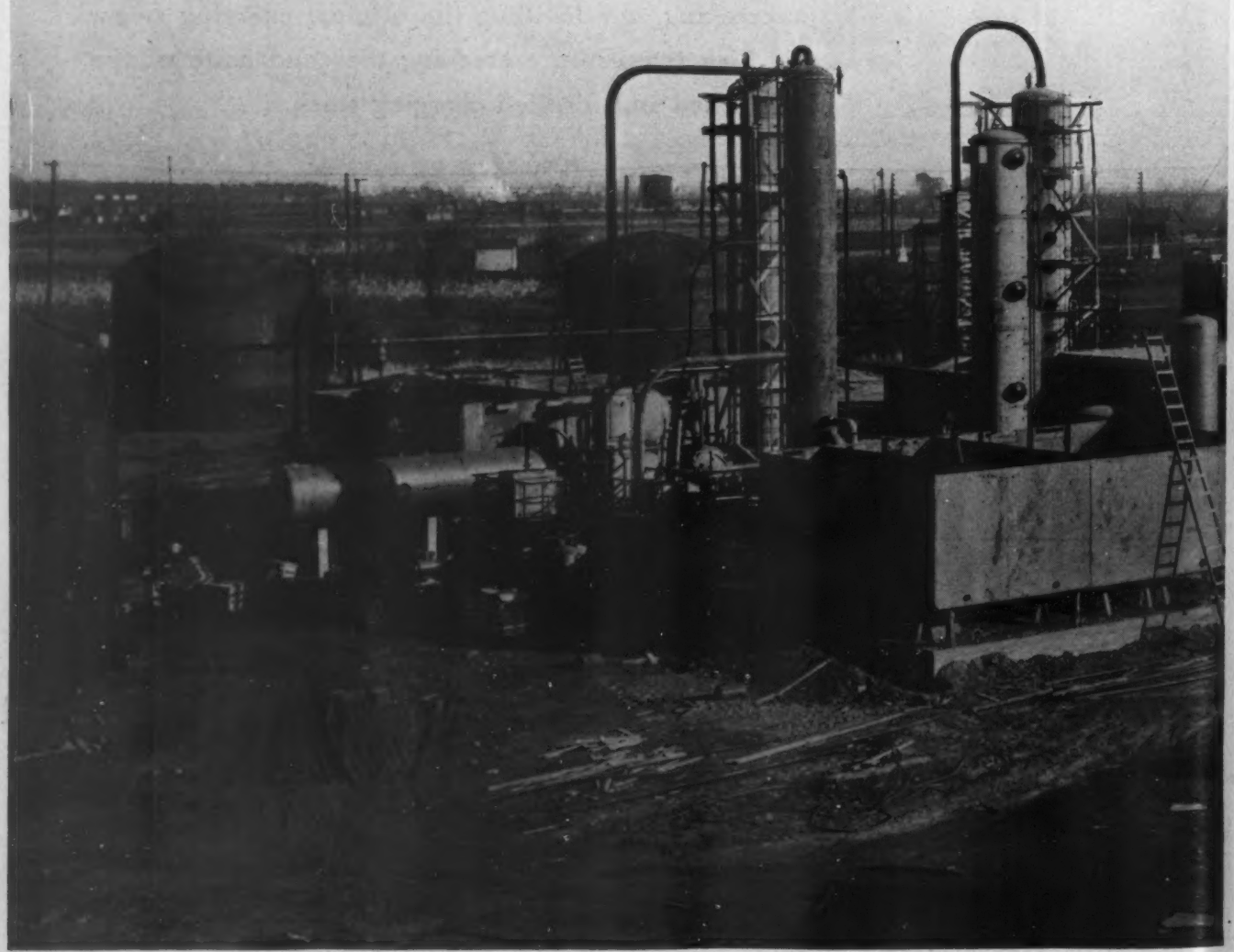

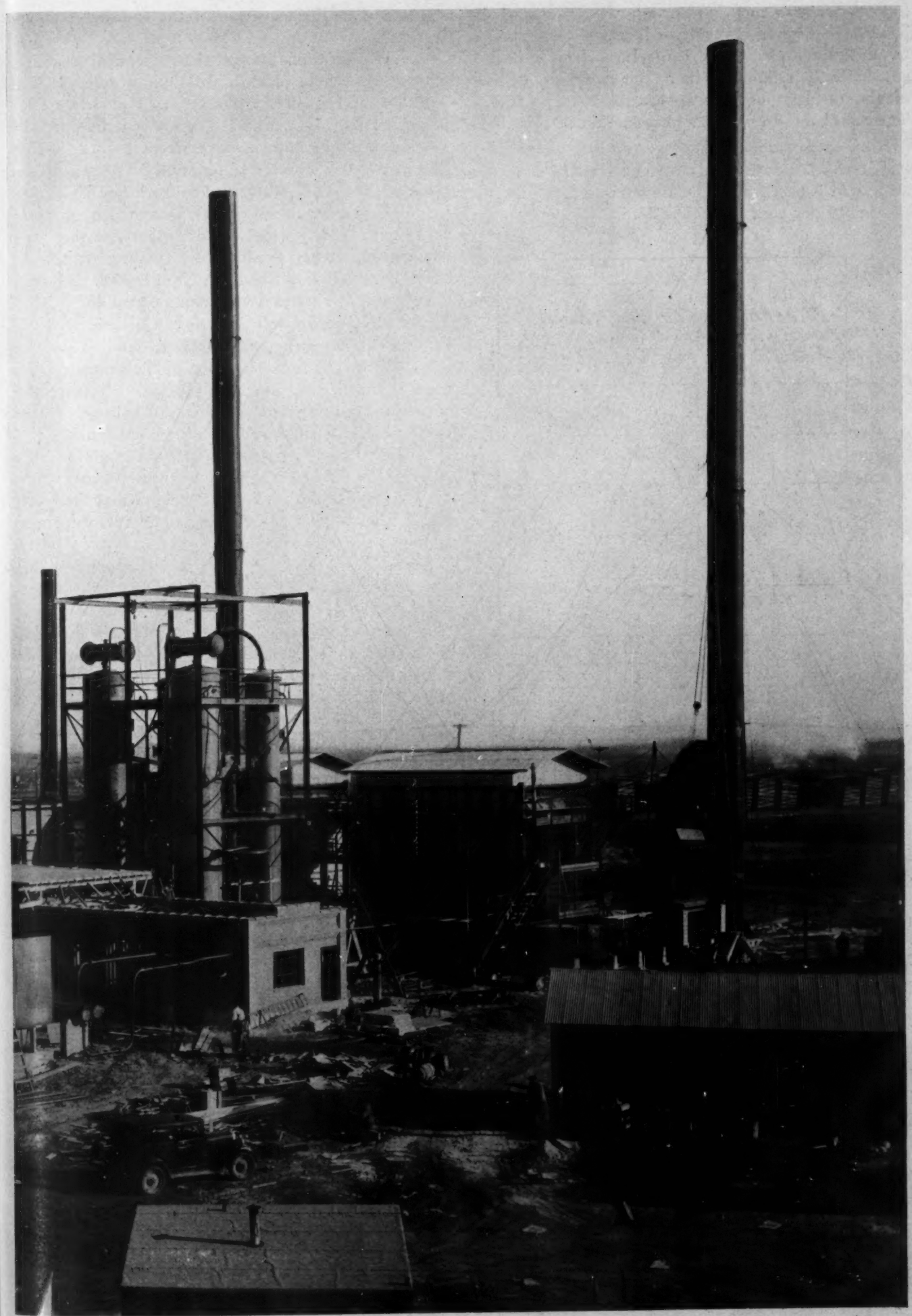

follows we will mention certain viewpoints which have developed as a result of the work. It should be understood that these conjectures have a different order of reliability than the previous experimental results, but they appear to us to be sufficiently probable to warrant introduction at this time.

It has been said that the acid treating of lubricating stocks is principally a chemical reaction[7] This statement is based upon the assumption that between 25 and 40 per cent of acid is actually consumed by

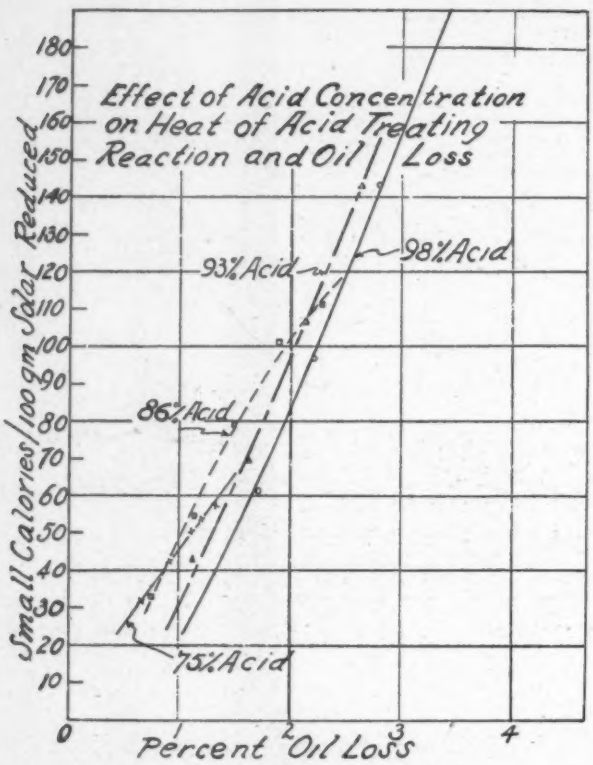

FIGURE 14

the reaction with oils and that large volumes of sulfur dioxide are liberated.[8] Furthermore, it is frequently stated that sulfur and oxygen are found to be highly concentrated in the sludges. In distinction to the chemical theory is the physical, or solution, theory,[9] which assumes that the major portion of the action consists in the absorption and subsequent solution of the asphaltic bodies in the acid in exactly the same manner as a soluble substance distributes itself between two immiscible liquids. Another possibility has been mentioned, viz., that bituminous bodies previously retained as (colloidal ?) particles in the oil are flocculated [10] [11] by the acid, which thus removes the colored materials.

Judging from the results of this work, we find it difficult to believe that the reaction is largely one in which sulfuric acid is a reactant. The loss of acid in the reaction is insufficient to sustain the chemical theory. Furthermore, the amount of sulfur doxide liberated represents a negligible part of the total amount employed, and the oil loss is not found to increase with the elevation of the treating temperature.

Every indication shows that chemical reaction with sulfuric acid plays a very minor role. In the work on the heat of the treating reaction, more than 95 per cent of the heat was found to be liberated in the course of one minute. Experimental work showed that at this temperature sulfonation [12] [13] does not take place with such rapidity. It is also improbable that polymerization between olefins promoted by sulfuric acid occurs to any great extent; otherwise the large changes in gravity produced by treating would not have been accomplished. Polymerization between olefins and aromatics seems more plausible.[14]

The physical, or solution, theory of acid treating is well supported by experimental data. Thus the color removed is less a function of the grams of acid than the concentration and volume. Plotting the per cent color removed against the volume of acid employed for a large variety of oils, the curves will be found to coincide approximately regardless of the color of the stock, provided the same acid concentration is employed throughout. The fact that the treating is enhanced by a lowering of temperature also supports the solution idea.

Several workers have supported the solution theory on the basis of results similar to the color removal curve (Figure 3), which they claim is typical of a solution process. Their contention is probably not well founded, since it can easily be shown that a curve of similar shape might obtain if the process were purely chemical.

What is believed to happen in the treating of lubricating stocks is: First, there is the production of substances having an indicator-like nature which increases the color beyond the stock color. This is the reactant which becomes yellow in color if the oil is made ammoniacal, and the presence of these bodies accounts for the characteristic maxima on the acid treatment curves previously mentioned. This, we believe, is practically all the "chemical" reaction which occurs, except under conditions discussed under the fourth step below. Second, there is a flocculation of the (colloidally ?) dissolved bitumens followed by their absorption by the acid to form a solution or emulsion. Third, color bodies other than bitumens containing chromophore groups are dissolved in the acid by preferential solubility. Fourth, if the quantity and concentration of the acid are high, some sulfonation and oxidation may take place.

If refining is largely a matter of the flocculation of bitumens, it should be possible to return these substances to the main oil body, restoring the oil to its original physical condition. Experiments were conducted to find out whether such was the fact. Samples of solar reduced stock were treated with 0.3 per cent, 0.5 per cent, 1.6 per cent, 2.0 per cent and 3.0 per cent by volume of 93 per cent acid. To these were added alcohol (95 per cent) and benzol

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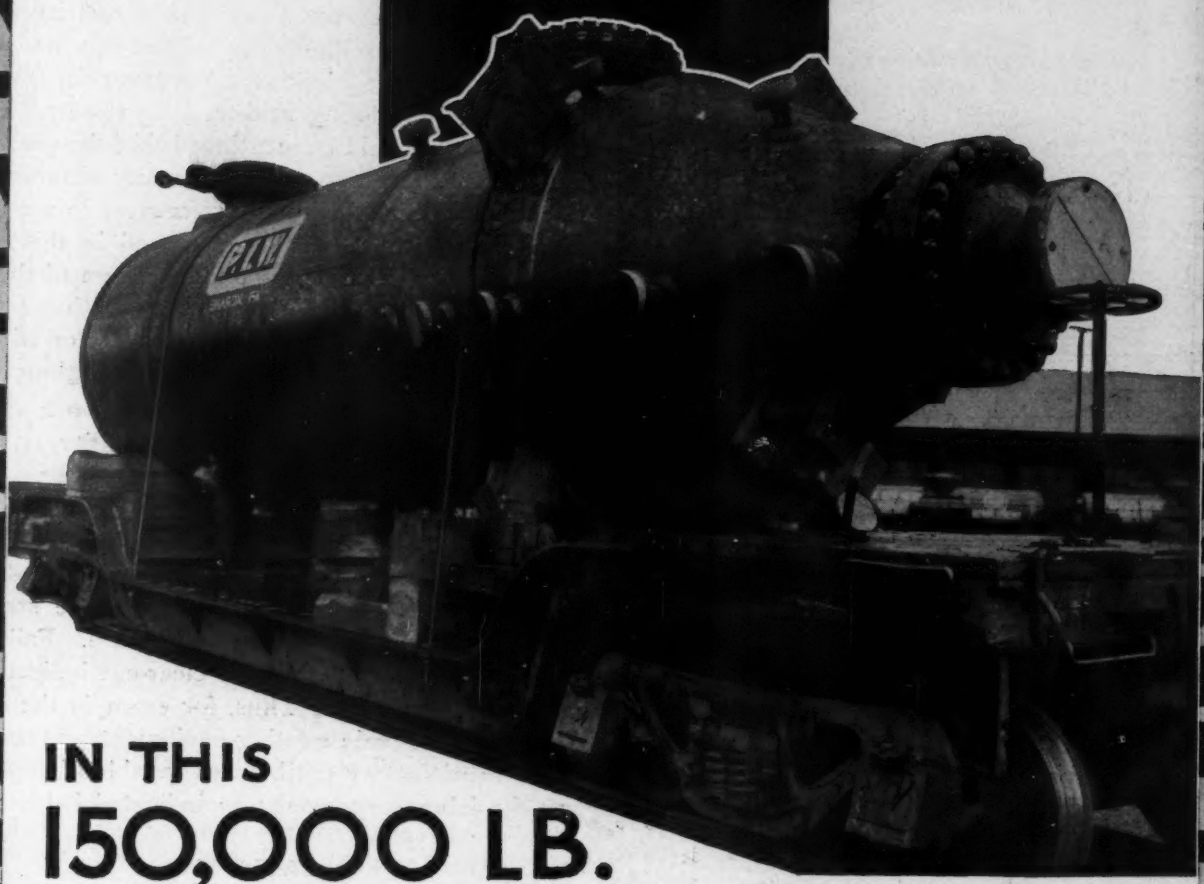

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in sufficient quantity to dissolve all of the sludge. Each mixture was then neutralized and washed and subjected to distillation at 350 mm. pressure in order to remove the solvents. The maximum temperature obtained in the distillation was 400° F. A blank was also run (without the addition of acid, but with all other factors the same). Inspection of the acid-treated samples showed that all of the sludge had

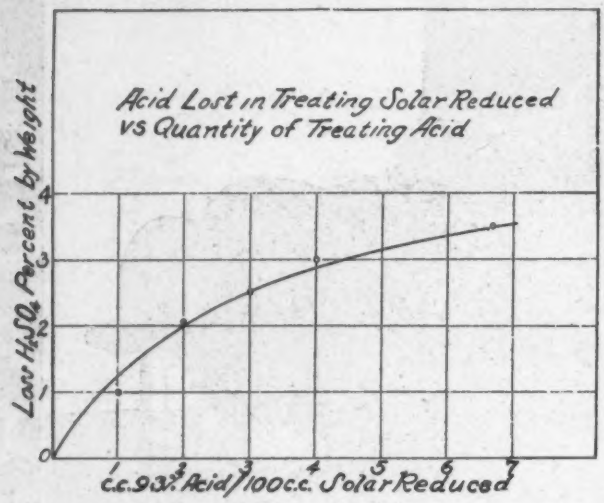

FIGURE 15

gone back into solution with the oil. Table I summarizes the results.

TABLE I

Reconstitution of Stock from Treated Oil and Sludge

Per Cent Acid by Volume	Color	Viscosity* 100 Deg. F.	A.P.I. † 60 Deg. F	Index of Refraction 29 Deg. C.
Virgin oil	170	286	25.30	1.49937
Blank	261	288	25.25	1.49930
0.3	294	297	25.12	1.49945
0.5	306	298	25.15	1.49950
1.0	297	301	25.04	1.49938
1.6	316	299	25.17	1.49930
2.0	348	302	25.07	1.49920
3.0	298	294	25.10	1.49840

*Pipette viscosimeter.
†Picnometer.

Inspection of the table indicates that the order of color change in the blank was the same as that found with the acid-treated samples. It will also be noted that there is no regularity of increase in color with increase in acid applied. Thus, a three cc. acid treatment when neutralized according to the above procedure showed almost the same color as a sample given only one-tenth the amount of sulfuric acid. While the results are capable of different interpretation, they present an interesting phenomenon which must be taken into account in any theory of acid treating. It need hardly be stated that the variation in gravity and index of refraction are within the limits of error of determination.

To show further that the oil was not markedly changed in character by the acid treatment and neutralization procedure specified above, the sample which was treated by one per cent of acid by volume and "reconstituted" was subsequently treated with an additional one per cent in the ordinary manner. This specially treated sample gave a 98 per cent yield of oil having an ammonia true color of 25.6, whereas the virgin oil treated in the identical way gave the same yield and an ammonia true color of 22.2.

OTHER APPLICATIONS

In concluding this paper in which we have sought to show a certain simplicity and regularity in the reaction of acid on lubricating oils, it may be well to point out certain obvious advantages in this new method of considering acid-treating results. In the first place, it should be mentioned that the procedure has been successfully applied to many different oils. Lack of space has prevented references to a number of interesting relationships discussed in this work. It is clear, for example, that the problem of the economical relationship between acid treating any oil and contact or percolation removal of color with absorbents becomes a matter of simple arithmetic.

Furthermore, since the laboratory work can be done quickly, with excellent reproducibility, and with the highest efficiency of application of the acid, it serves as a true standard of accomplishment for plant operation. It has been shown, for example, in the work of this company that carefully controlled plant operations can very nearly approach the standard set by these treatments of 100 cc. of oil. Failure to accomplish such a result is a clear-cut indication of poor plant operation. Thus, for example the operation of a large-scale treating equipment was not considered satisfactory until it was capable of approaching the laboratory results as indicated below:

TABLE II

Comparison of Laboratory and Semi-works Treatment

Pounds of Acid Per 50-Gal. Bbl. of Oil	Laboratory Ammonia Color	Semi-works Ammonia Color	Kind of Oil
13.0	2.2	2.9	Pressed heavy distilled
7.6	5.0	4.6	Pressed heavy distilled
16.0	12.1	12.5	Solar reduced
8.0	19.5	26.5	Solar reduced
4.0	44.0	54.5	Solar reduced

From results which are not included in this paper, it was possible to decide whether or not two-stage application of acid was justified for this particular installation.

In another instance the procedure was employed to determine the amount of acid required to reduce a long series of overhead lubricating cuts to require color. The decrease in viscosity with treating and other factors of importance at that time were noted to determine the particular distillation column adjustment to produce the most economical cut of high

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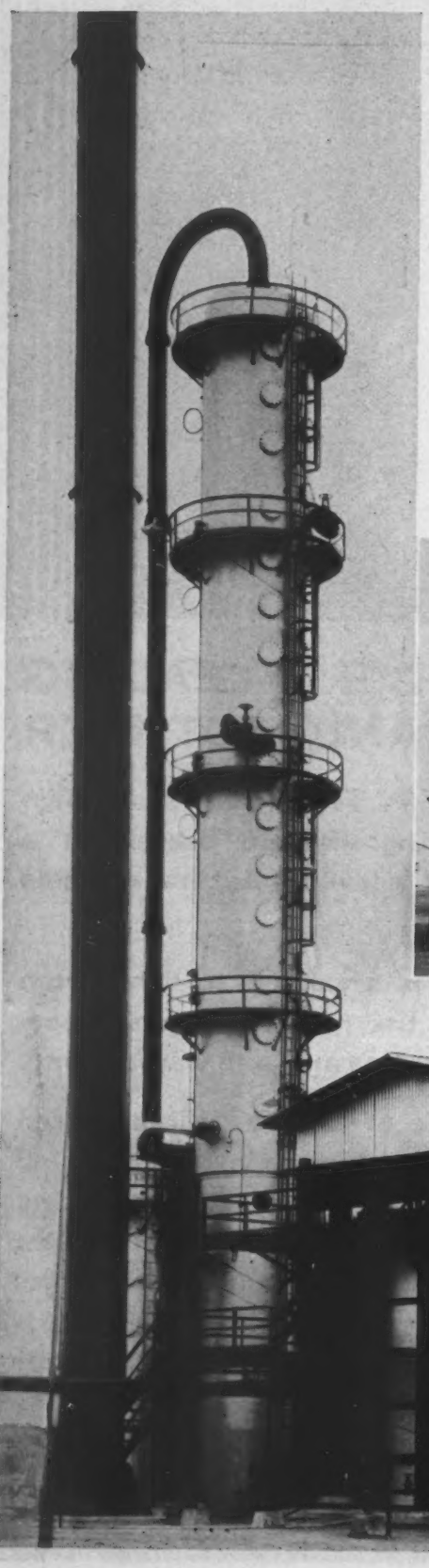

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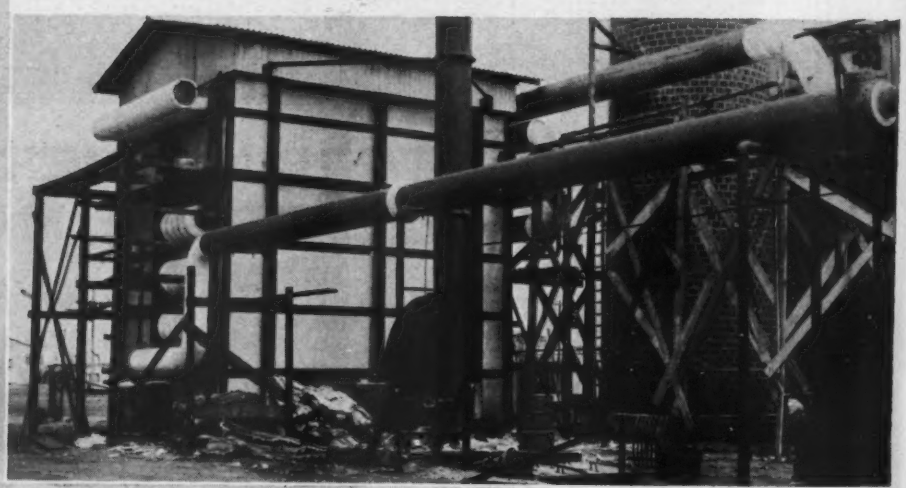

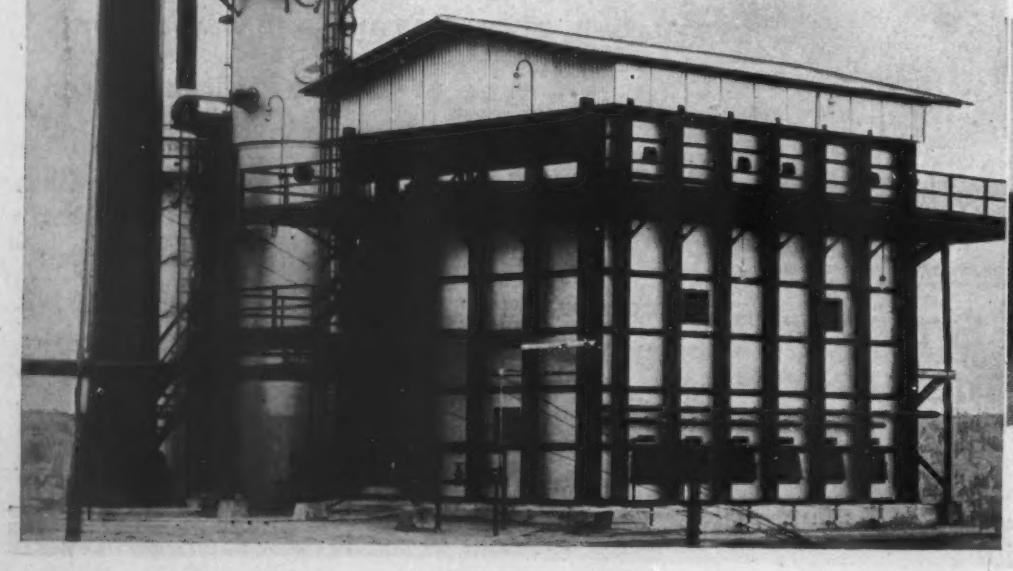

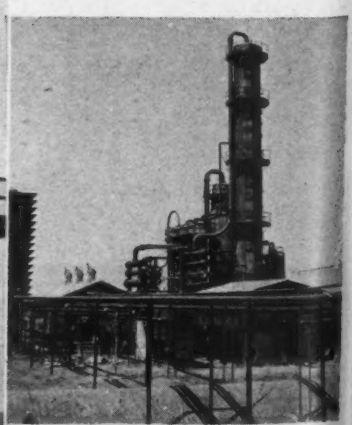

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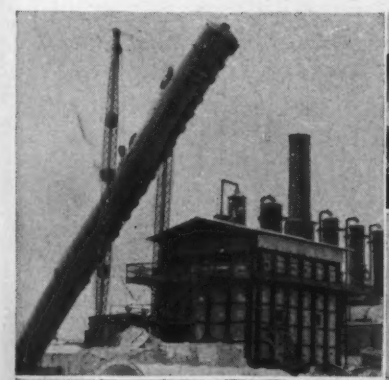

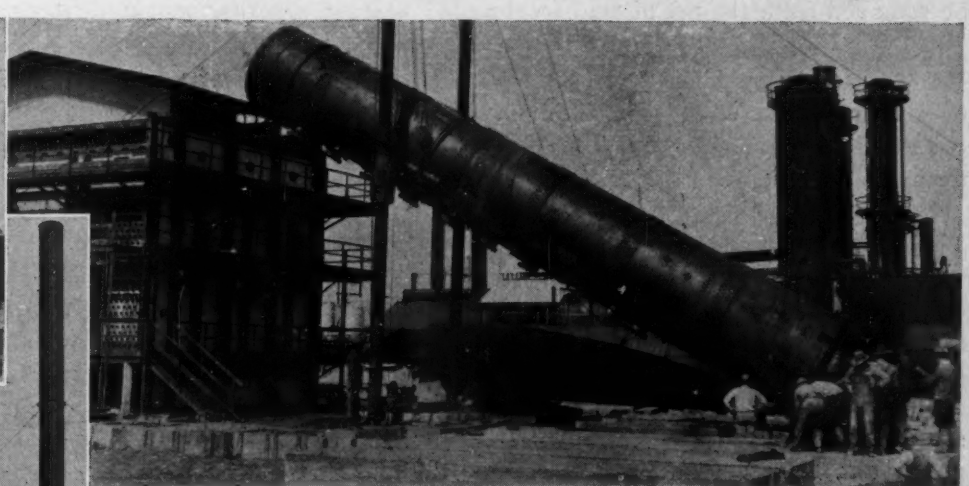

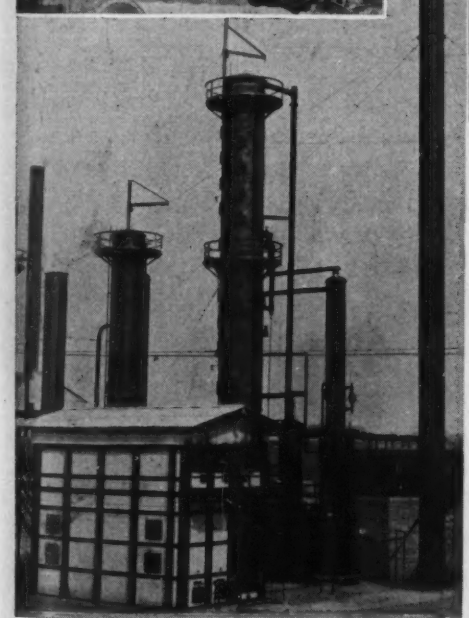

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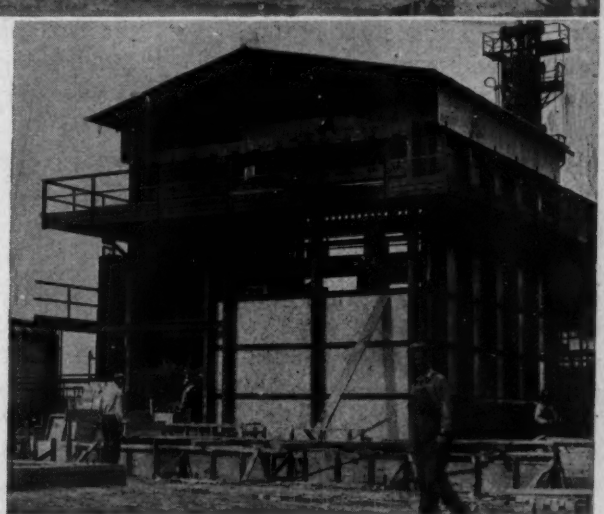

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viscosity oil as respects color, viscosity, treating-acid consumption, and over-all viscosity oil yield.

The true color scale adopted in all of the treating work has also been of distinct value in connection with the distillation of heavy oils. Thus the extent by which a particular stock darkens under given distillation conditions is clearly shown by making a color balance involving the yield and color of each of the cuts. From such determinations clean-cut decisions can be made as to whether certain methods of distillation will finally produce improved materials for the acid treating plant.

It is planned to continue the work, part of which has indeed become routine in connection with our plant operations, in the hope and with the promise that much of the speculation and all of the lore can be removed from the art of acid treating.

SUMMARY

1. A method has been developed which is capable of measuring the color of any oil in terms of true color units. True color units may be expressed in terms of N. P. A. colors.

2. Employing this system of color measurement, a laboratory treating procedure has been developed which has been useful in controlling plant-treating conditions. It enables one quickly to determine for any oil the quantity and concentration of acid necessary to obtain a specified color or oil yield. The samples handled are large enough for complete inspection, and the results are comparable with plant practice.

3. In treating solar reduced stock the first increment of acid produces a sour oil color which is higher than initial color of the untreated oil. Thereafter the color decrease as more acid is added.

4. On a weight basis, 93 per cent sulfuric acid is superior to 98 per cent as a reagent for the removal of color from solar reduced stock. The sequence of acid concentrations in their order of decreasing efficiences as reagents for color removal (restricted to solar stock only) is 93 per cent, 98 per cent, 91 per cent, 86 per cent, 83 per cent, and 75 per cent. For naphtha flux bottoms, 98 per cent acid is superior to lower concentrations.

5. As the concentration of the treating acid increases, the oil loss increases. The loss is primarily a function of the concentration of acid rather than the weight of sulfuric acid in the acid used.

6. The effect of treating temperature on solar reduced stock with all concentrations af acid is not very pronounced. For normal amounts of acid up to two per cent by volume, the color changes but slightly in the temperature range from 60° F. to 120° F. For volumes of acid in excess of this amount, lower temperatures produce more favorable results, providing the viscosity of the oil is reduced by fluxing with naphtha or water white. The oil loss does not change with variations in temperature.

7. As the volume and concentration of the acid increase, the A. P. I. gravity of the finished solar oil increases. The first increment of acid (up to one per cent by volume) produces a proportionately larger increase in A. P. I. gravity than the larger volumes of acid. Stronger acids produce greater changes in gravity than the weaker acids.

8. As the volume and concentration of treating acid increase, the viscosity of the finished solar stock decreases. This change is almost a linear function of the acid volume. The effect of the first increment (up to 0.5 per cent) of 75 per cent acid, however, is to increase the viscosity; thereafter additional acid decreases the viscosity.

9. The refractive indices of finished acid-treated solar oils decrease as the amount and concentration of acid increase.

10. The removal of color with various concentrations of acid does not appear to be definitely related to changes in gravity, for the greatest color removal per unit volume of acid is not accompanied by the greatest change in gravity.

11. The heat of the acid-treating reaction is directly proportional to the oil lost by reaction in the treating, and for any given oil loss the heat of reaction is practically equal for all concentrations of acid.

12. The change in gravity is directly proportional to the oil treating loss, and for any given loss the change in gravity is practically equal for all concentrations of acid.

13. For 93 per cent treating acid, the acid lost or consumed by reaction with solar reduced stock varies from 1 to 3.5 per cent of the initial weight for treatments ranging from 1 per cent to seven per cent by volume of treating acid. The acid consumed is not proportional to the color removed. The loss due to oxidation, as indicated by the formation of sulfur dioxide, varied from 0.06 per cent to 0.22 per cent for tests with 0.25 per cent to five per cent acid by volume.

14. Experiments on the reconstitution of solar reduced stock, whereby sludge is re-dissolved into the oil, shows that the oil is not appreciably changed as a consequence of the action of the acid.

ACKNOWLEDGEMENT

We are indebted to H. F. Dure for his assistance in the early stages of the experimental work.

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John C. Campbell, *President*

We agree with Pusey and Jones

The Pusey and Jones Corporation, Wilmington, Delaware, famous builders of ships since 1848, published this statement in the August 1930 issue of Marine Engineering and Shipping Age:—

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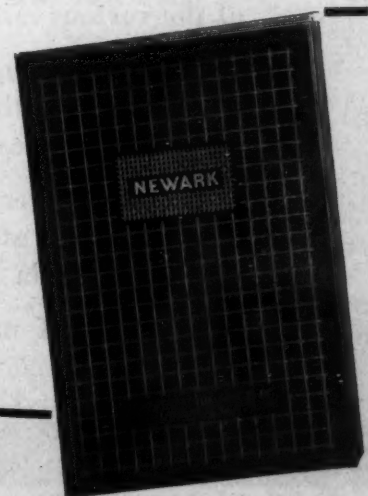

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The 1930 Edition, the supply of which has been exhausted for some time, met with a splendid response. Letters from refinery and gasoline plant staff men all over the world advised us that the 1930 Edition was of real value. The 1931 Edition will be an improvement over last year's in that it will contain more descriptive matter on equipment and materials used in refineries and gasoline plants and that additions will be made to the tabular content in the back of the catalog.

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Flue Gas for Reducing Fire Hazard

By A. E. PEW, Jr.
Sun Oil Company, Philadelphia

ABSTRACT

FOLLOWING a policy of intensive development of methods and procedures for the elimination of potential causes of fires in oil refineries, the problem of preventing the presence of explosive mixtures is discussed and methods for its solution suggested. Three practical and economical systems are described.

One of these methods consists in the use of gas as an enrichment agent and as the displacement medium in tank breathing, thus eliminating the presence of air. The second and least used method consists in forced circulation of air through tanks containing small percentages of dissolved gases, thus preventing the tank atmosphere exceeding the lower explosive limit. The third and most widely applicable method consists in the generation of flue gas and its use to purge air or oil vapors from various types of refinery equipment, including tank ships and barges.

Detail drawings and photographs are given as well as typical operating instructions.

Specific installations of the various methods are given, together with the classification of the equipment each method is best suited to protect.

The hazards eliminated are the danger of discharge from static and bound charges, the spontaneous ignition of pyrophoric iron and sulfur corrosion compounds, all being ignition agents in the presence of explosive atmospheres. The flue gas system makes equipment safe for repair and inspection without the use of steam.

This paper was prepared for presentation at the Eleventh Annual Meeting, American Petroleum Institute, at Chicago, November 12, 1930.

THE purpose of this paper is to describe various methods of combating fire hazards by elimination of explosions resulting from the presence of explosive mixtures of hydrocarbons and air in containers of various types used in the oil refining industry. Special emphasis is given to the use of flue gas for this purpose, with a general description of methods used when flue gas is not practical.

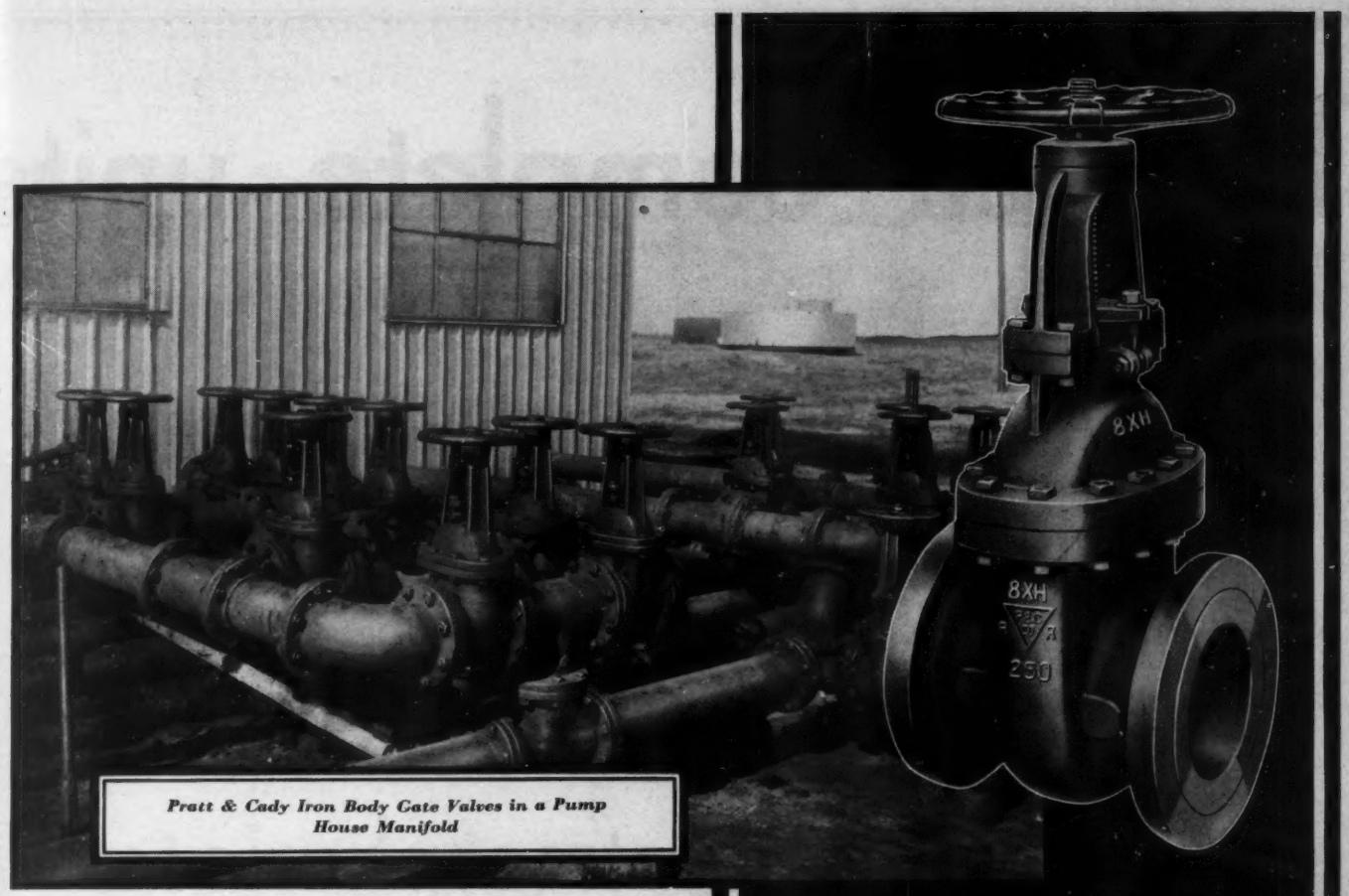
The presence of explosive atmospheres in containers is not in itself a particularly hazardous condition; but when considered in connection with the many unknown factors of static charges, bound charges, stray currents, pyrophoric iron-sulfur compounds, any of which might cause the ignition of the explosive mixture and some of which are always present, a real hazard exists. The conveyance of nitroglycerin in an automobile is not particularly dangerous, providing it is not subjected to shocks; but it is not an occupation generally found desirable. We feel much the same way in connection with explosive mixtures of air and gas or vapors.

The elimination, to as great an extent as practicable, of conditions making it possible for static charges to accumulate, should be attempted by establishing permanent recording stations in refineries to learn the exact situation. Data thus obtained will indicate the proper steps to be taken to ground such lines as are collectors of stray currents, and even to eliminate the electrical leakage at its source.

The use of aluminum wires in agitators to neutralize the static field above the oil surface, the proper bonding of trolley lines where they cross railroads entering refineries, track bonding, car bonding, etc., remove substantially the hazard of explosive mixtures by eliminating the factor which causes them to explode. But such methods are not practicable, or even possible, in the great variety of refinery operations.

Efforts were, therefore, directed towards preventing the formation of explosive mixtures in operations not susceptible to being safeguarded by static and bound charge elimination. The increased use of vapor-tight steel-roofed tanks, fractionating towers, gas recovery systems, and high sulfur crudes accounts for the importance of this problem.

The hydrocarbon vapors normally present in oil refineries are explosive when their concentration in air is between one and 15 per cent. Higher concentrations tend to burn, but not to explode. The follow-



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ing table shows limits of explosibility of various hydrocarbons.

Hydrocarbon	Lower Limit (Per Cent)	Upper Limit (Per Cent)
Methane, CH_4	5.30	14.50
Ethane, C_2H_6	3.20	12.50
Propane, C_3H_8	2.40	9.50
Iso-Butane, C_4H_{10}	1.65	.....
N-Butane, C_4H_{10}	1.90	8.50
Iso-Pentane, C_5H_{12}	1.32	.....
N-Pentane, C_5H_{12}	1.40	8.00
N-Hexane, C_6H_{14}	1.14	.....
Ethylene, C_2H_4	3.00	22.00
Propylene, C_3H_6	2.13	.....
Iso-Butylene, C_4H_8	1.61	.....
Amylene, C_5H_{10}	1.30	.....
Acetylene, C_2H_2	2.60	73.00
Hydrogen, H_2	4.00	80.00
Carbon monoxide, CO	1.00	73.00
Gasoline vapor	1.50	6.00

The above data are taken from various sources, including International Critical Tables. In all cases the maximum range is listed. Prevention of explosive mixtures may be accomplished by increasing the percentage of the hydrocarbon constituent above the upper limit, by diluting the mixture below the lower limit, by increasing the air percentage, and by lowering the oxygen content by the use of an inert gas such as flue gas. All three procedures are used, as conditions do not permit any one to be a "cure all," but the latter system has the greatest variety of application. The use of the first two will be briefly outlined.

TANK PROTECTION

Receiving tanks, being subject to constant variations in quantity contained, show explosive mixtures in a great number of cases. In most modern refineries such tanks are connected to gas-recovery systems. It is thus very easy to inter-connect these tanks with the lean gas holder and, by the use of automatic valves, allow the gas from the tank to pass to the compressor when the tanks are filling with oil and then, when pumping out, to fill the void with lean gas from the gas holder. Two of our refineries are substantially completely equipped in this manner, and the results have been most satisfactory —no explosive mixtures having ever been found since the system has been used. The saving in vapor recovery also is a substantial extra benefit. Before this method was used, we had tanks which were fully equipped with steel roofs and breather valves explode while pumping out, with definite evidence that the explosion was due to the existence of a small volume of explosive mixture near the breather valve—this being ignited by the oxidation of sulfur-iron compounds on the steel roof. These explosions were not violent, but tore off one or two roof plates resulting in the ignition of the tank's contents. By preventing the access of air, this hazard has been eliminated. The use of this method is limited to tanks whose contents are not subject to rigid flash specifications, as we have found that the light gas used has a tendency to lower the closed cup flash of the produce without affecting the open cup flash. Receiving tanks for gasoline, re-run naphthas, cracking stocks, re-cycle stock , etc., are the logical field for this application. Tanks containing finished light oil products are not subject to the presence of sulfur-iron compounds, and thus not so susceptible to ignition in the event of the presence of explosive mixtures. We have made no protective installations on such tanks, other than for vapor-purging purposes as described later.

Heavy fuel oil and lubricating oil tanks have never shown the presence of explosive mixtures and, accordingly, are not discussed in this paper.

Some tanks, such as receiving tanks for pressure still bottoms, are a hazard due to the presence of small amounts of residual gas in the oil, especially where vapor-tight roofs are used with conventional breather valves. These tanks show explosive mixtures on the lean side. Our practice in this case is to use a small rotary air blower, operated continuously or intermittently as conditions require, to keep up circulation in the tank and prevent the accumulation of gas responsible for the explosive condition. The quantity of gas is very small, and does not warrant connection to the gas system. A 500 cubic foot per minute blower operating at 1½ inch water pressure with a ½-h. p. motor, costing installed $115, is ample for an 80,000 barrel tank under our conditions. The same system is used on gas oil receiving tanks from crude stills when iron-sulfur compounds liable to oxidation are not present.

The applications so far discussed outline, in general, our use of the method involving enriching the hydrocarbon content of an air-vapor mixture above the upper limit of explosibility, and the method of increasing the ratio of air to hydrocarbon content below the lower limit.

As all operators know, a major problem to be faced in refinery operation is that of gas-freeing containers for inspection and repair after shut-down, and freeing them of air before starting up. The use of flue gas for this purpose has been adopted by our company and extensively used during the past year. The system has been an entire success, and due to the ease and simplicity of operation, is believed to offer a wide application both for refineries and ships.

The method consists in the generation of an inert gas as a product of combustion, viz., "flue gas," having a carbon dioxide content of approximately nine to 13 per cent, oxygen two to eight per cent, and the remainder chiefly nitrogen. The gas is generated in a furnace, and cooled in a water washer which also removes the soot and corrosive sulfur dioxide. The gas is then used to displace air or vapors in the

A FOUR UNIT CRACKING PLANT being built by Kellogg for a British Company in the Near East. Abroad, as in this country, the performance of Kellogg equipment is establishing new refining records.

The M.W. KELLOGG CO., *225 Broadway, New York*

LOS ANGELES, CAL., 1031 SOUTH BROADWAY TULSA, OKLA., PHILTOWER BUILDING

container to be conditioned. The displacement is considered complete when exhaust gases from the container check with exhaust gases from the generator. Tests show that, with a flue gas containing as low as six per cent carbon dioxide and as high as 12.7 per cent oxygen, explosive mixtures are not formed with gasoline vapors in concentrations of from ½ per cent to 90 per cent. This clearly indicates that, even with exceedingly poor combustion in the generator, it is possible to obtain absolute safety.

GENERATORS

The generators used for both land and marine purposes are essentially the same. Figure 1 shows a

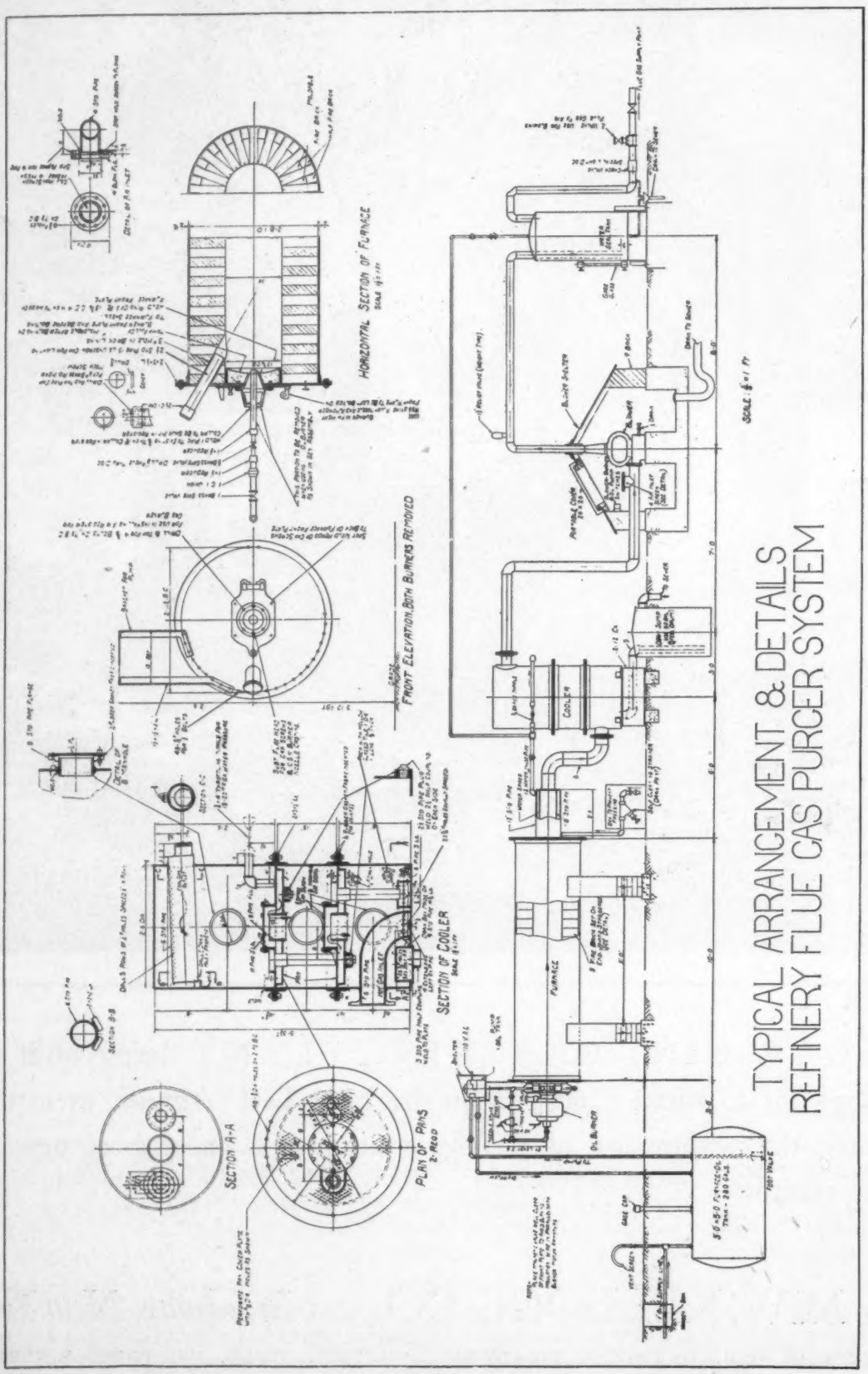
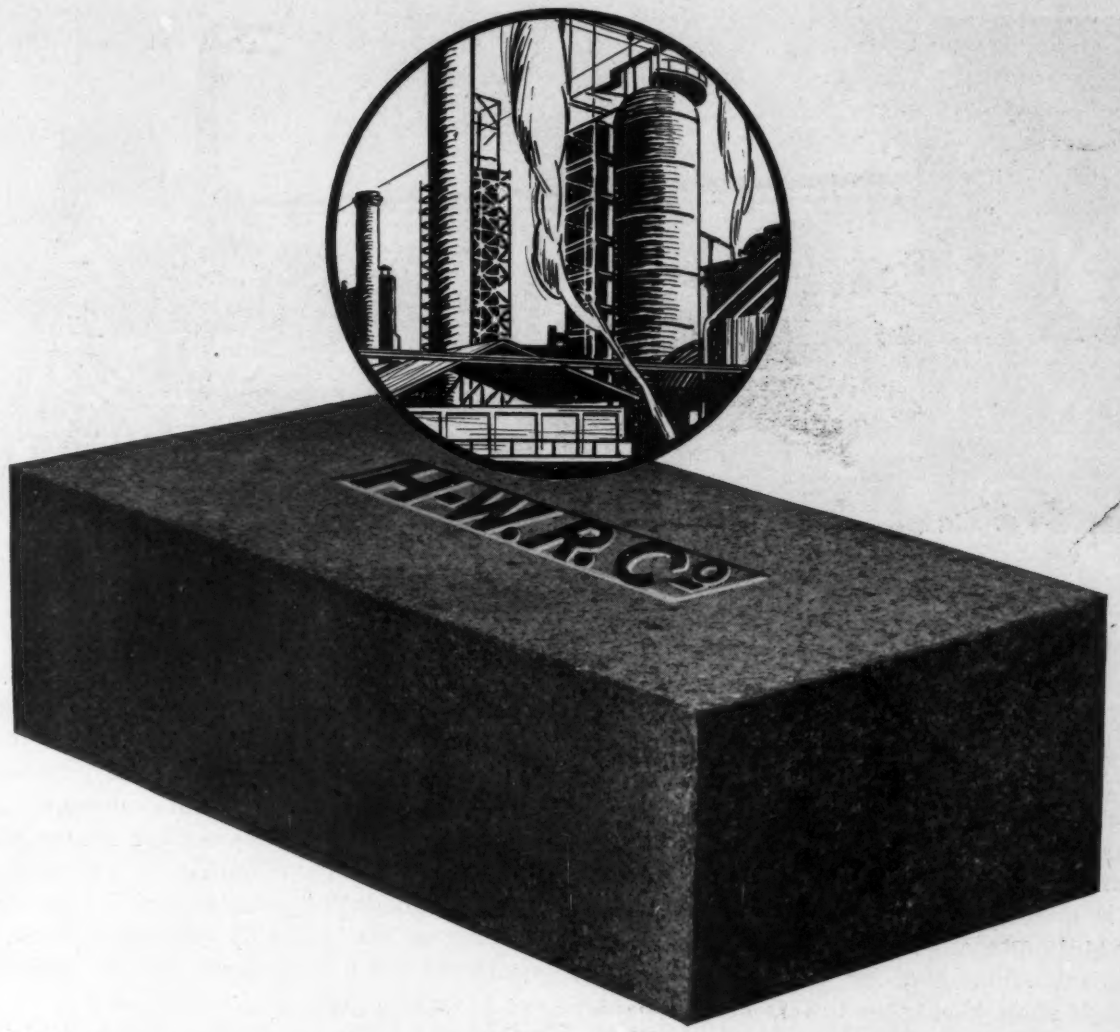


FIGURE 1



You'll Agree...This Is Tough Service

You have to kneel to look through the peephole in front of one of the boiler settings in this big Oklahoma refinery. The boilers are running at capacity. The fire is to all appearances a normal one.

But ask the engineer what these boilers are burning. It's oil—heavy residues mixed with sulphuric acid, so sludgy in character that it must be kept hot to prevent clogging of the feed line, so corrosive that special pipe must be used to convey it to the boilers. Special bronze burners are required to burn it. This extraordinary mixture demands a firebrick of unusually high character—Harbison-Walker Walsh XX is being used.

There is a Harbison-Walker brick to meet every refinery requirement—fireclay brick for still and boiler settings—high-alumina brick to meet unusually severe conditions—refractory linings for roasters and kilns—acid-proof brick for lining acid equipment—and Firebond and Thermolith high temperature cements for bonding brickwork. Our engineering staff will gladly aid in the selection of the correct refractory.

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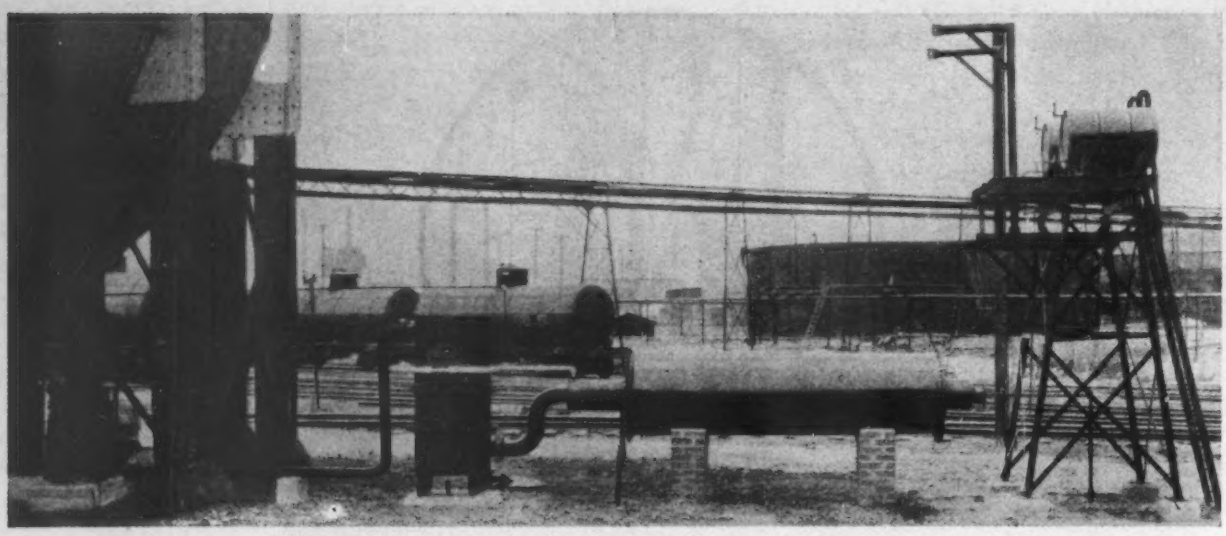

FIGURE 2—*Gas Header Purger System, Marcus Hook*

typical generator. The unit consists of a fuel or gas burner system, a furnace, a water cooler and washer, a blower and a seal tank. The drawing gives dimensions and complete details for a unit having a capacity of 180 cubic feet of free gas per minute against a discharge pressure of three pounds per square inch. Such a unit is adequate for most refinery purposes, and is installed permanently. Our practice is to install one such generator to protect four pipe still units, one per unit of twelve 1,000 barrel-cylindrical stills, one for two lubricating oil plants, each plant having 10 towers and 10 vaporizers. The generators are built as shown in Figure 1. The flue gas is carried through a manifold connecting into the base of the fractionating tower just above the maximum oil level. The purger thus washes the tower, condensers, gas separators, and lines, following the same flow line as the oil does in operation, and leaving the system through the gas stack or receiving tank vent. The system is used before starting up the tower, and when shutting down thus displacing air in one instance and gas in the other. Tar stills or other stills charging batch hot oils are filled with flue gas before and during charging, thus removing all air. The time required to displace air before starting depends, obviously upon the size of the container and the generator. The quantity of flue gas required for air-purging a container is about 2½ volumes, and for gas-freeing an oil tank or gas holder 3¼ volumes are used. These quantities hold, in general, for the different units we have installed.

A container which has been washed with flue gas cannot be entered by men until it is freed of the gas. This is accomplished by shutting off the fire in the generator and allowing the blower to force air into the container. If the container has manholes or hatches, these are usually opened. Flue gas being heavier than air will, for example, leave a tank by the bottom manhole and air will enter through the

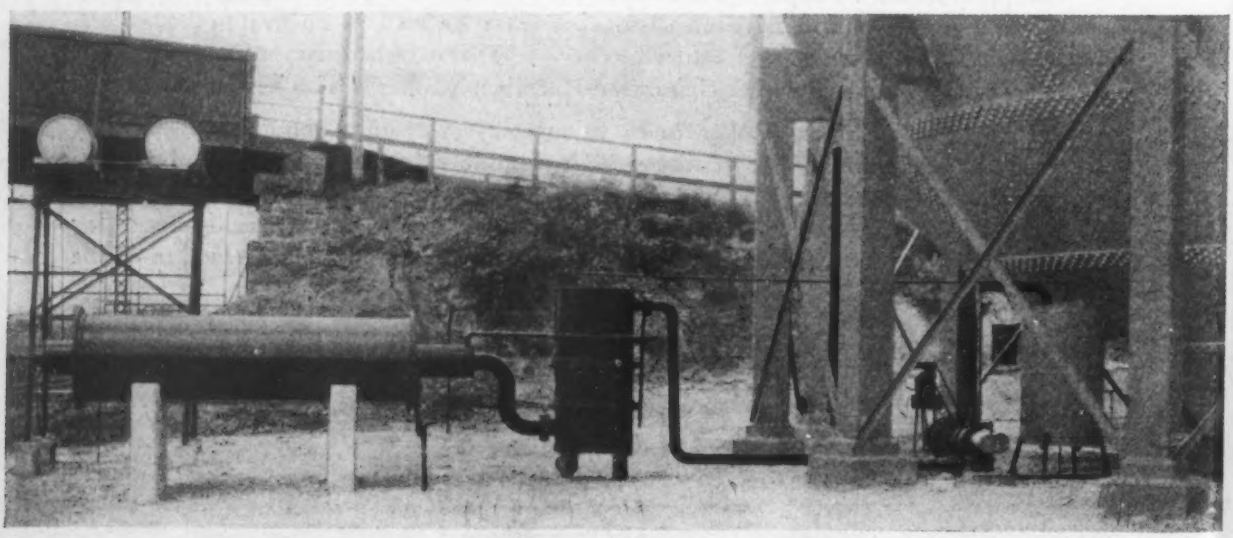

FIGURE 3—*Gas Holder Purger System, Marcus Hook*

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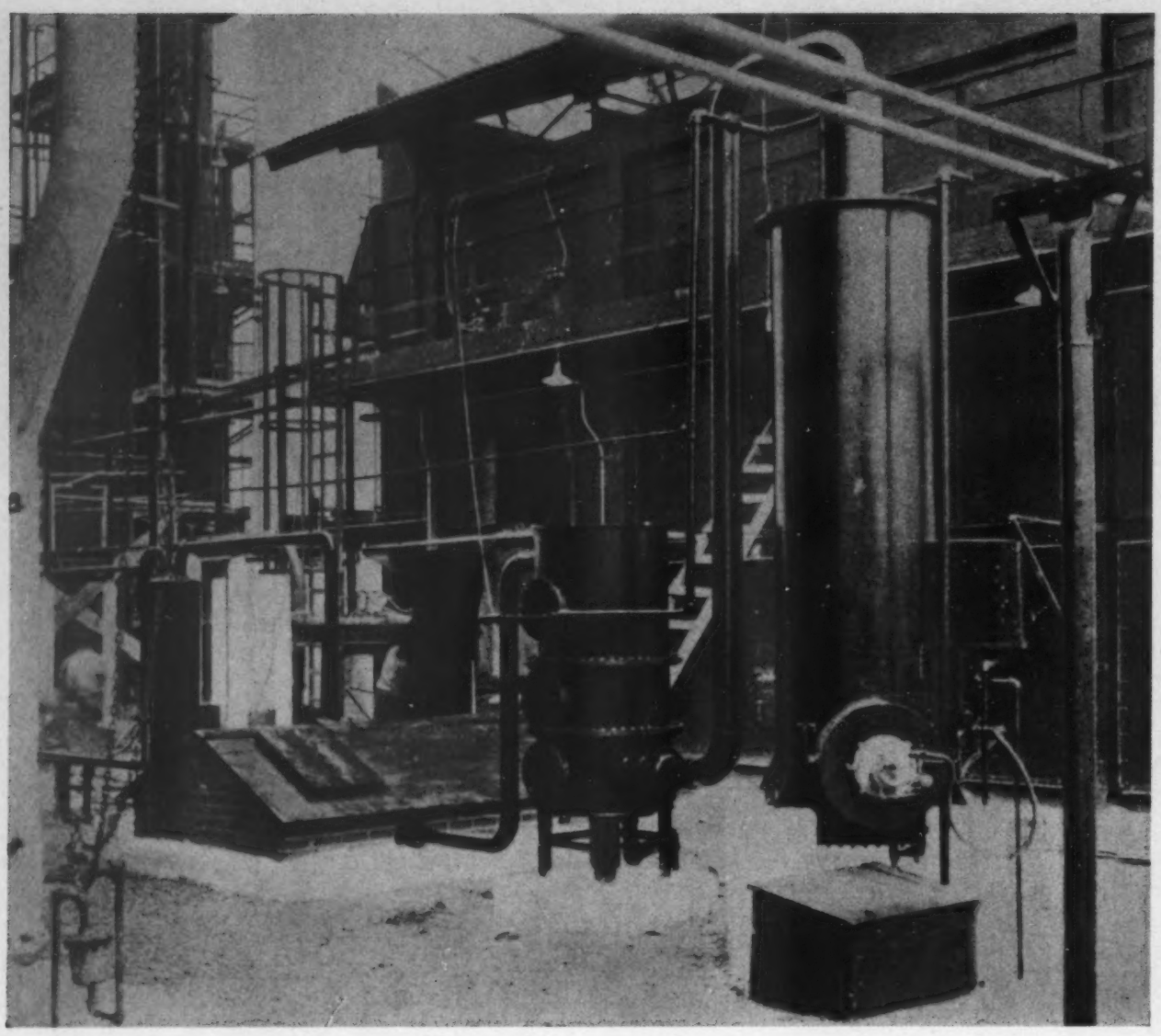


FIGURE 4— *Purger System Showing Vertical Type Furnace*

top hatch. The use of the blower to force the air into the tank gives circulation and speeds up the purification operation. From 1½ to 2½ volumes of air per tank volume results in a safe condition. Containers thus prepared are always tested before men are allowed to enter. Flue gas will not supply enough oxygen for respiration, and may contain some carbon monoxide. Suffocation is more apt to result from exposure to the flue gas than is poisoning from exposure to the carbon monoxide. The use of the iodine pentoxide method gives a quick and accurate test for carbon monoxide, while the regular Orsat method is used for testing the carbon dioxide content. We have had no accidents of any kind in this connection, but attention must be given to the potential hazard in operating instructions.

Tanks which are being emptied for repairs are gas-freed by the use of flue gas, blowing it in at the bottom through the swing line or through a special connection and allowing it to exhaust *through the flame arrester* on the regular breathing valve. This is important, as at the beginning the gases are inflammable, though not explosive.

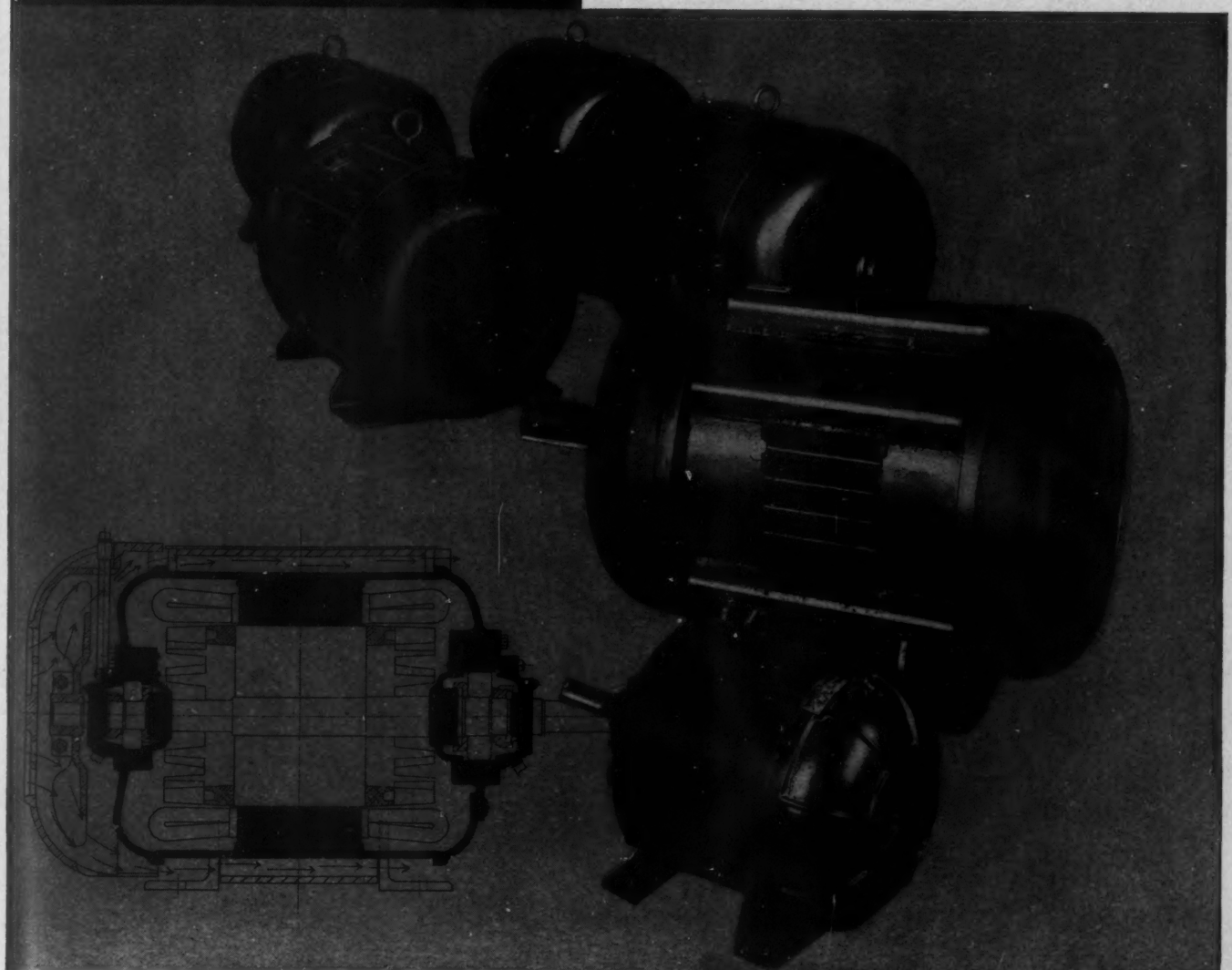
Most large refineries which have cracking plants use gas holders for the lean gas. These holders from time to time require inspection and repairs, as does the gas-piping system. The gas holders used by our company are of 65,000 cubic feet capacity, 38 feet in diameter, and 70 feet high, with hemispherical heads, operating at 50 pounds pressure. These holders are carefully inspected for corrosion every three months, and the purger is used to gas-free them after shutting down and air-free them before starting up. Each holder has its own permanent generator, which is also used to wash the gas lines and the gas recovery plants.

A number of our towers are operated under vacuum. When shutting the plants down the vacuum is broken with flue gas, thus removing the hazard of air entering, as well as effecting a time saving and eliminating the use of steam for this purpose.

For many of the applications of flue gas outlined

Eliminate motor shutdowns

In petroleum industries, especially, is uninterrupted motor operation of paramount importance. » » » That is why Wagner type CP air-jacketed motors are preferred by the leading petroleum engineers, particularly for pumps which must be kept going whatever the atmospheric conditions may be. » » » For Wagner CP air-jacketed motors are so built that nothing obstructive or injurious can find its way into the motor in sufficient quantity to require frequent removal. As the cross-section drawing illustrates (in this case showing one of the smaller sizes), these CP motors are provided with two frames, an outer frame which guides



a strong cooling draft over the motor, and an inner frame with clearances around the shaft only, clearances thru which nothing obstructive or injurious can get into the motor because of seals and grease packing. On larger sizes, a fan is provided at each end, the air exhausted around the periphery of the stator, as illustrated by the larger motors in the accompanying picture. » » » These Wagner CP air-jacketed motors, so indispensible for the elimination of frequent motor shutdowns and the lowering of expensive motor maintenance, are fully described in a new edition of Wagner Bulletin 151, copy of which will be sent upon request.

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above steam was formerly used. Steam for this purpose is costly compared to flue gas, and is not certain. It is well established that a temperature of at least 170° F. must be obtained when using steam before the container is reasonably safe. Condensation rates are high, and the danger of vacuums forming in event of steam failure must be considered. The removal of condensate is also to be considered. For example, in steaming out a fractionating tower the condensate collects on trays and gives trouble when starting up again. Last year a prominent company lost a large tower due to the sudden vaporization of water when hot oil was started in. A number of towers have experienced serious accidents due to

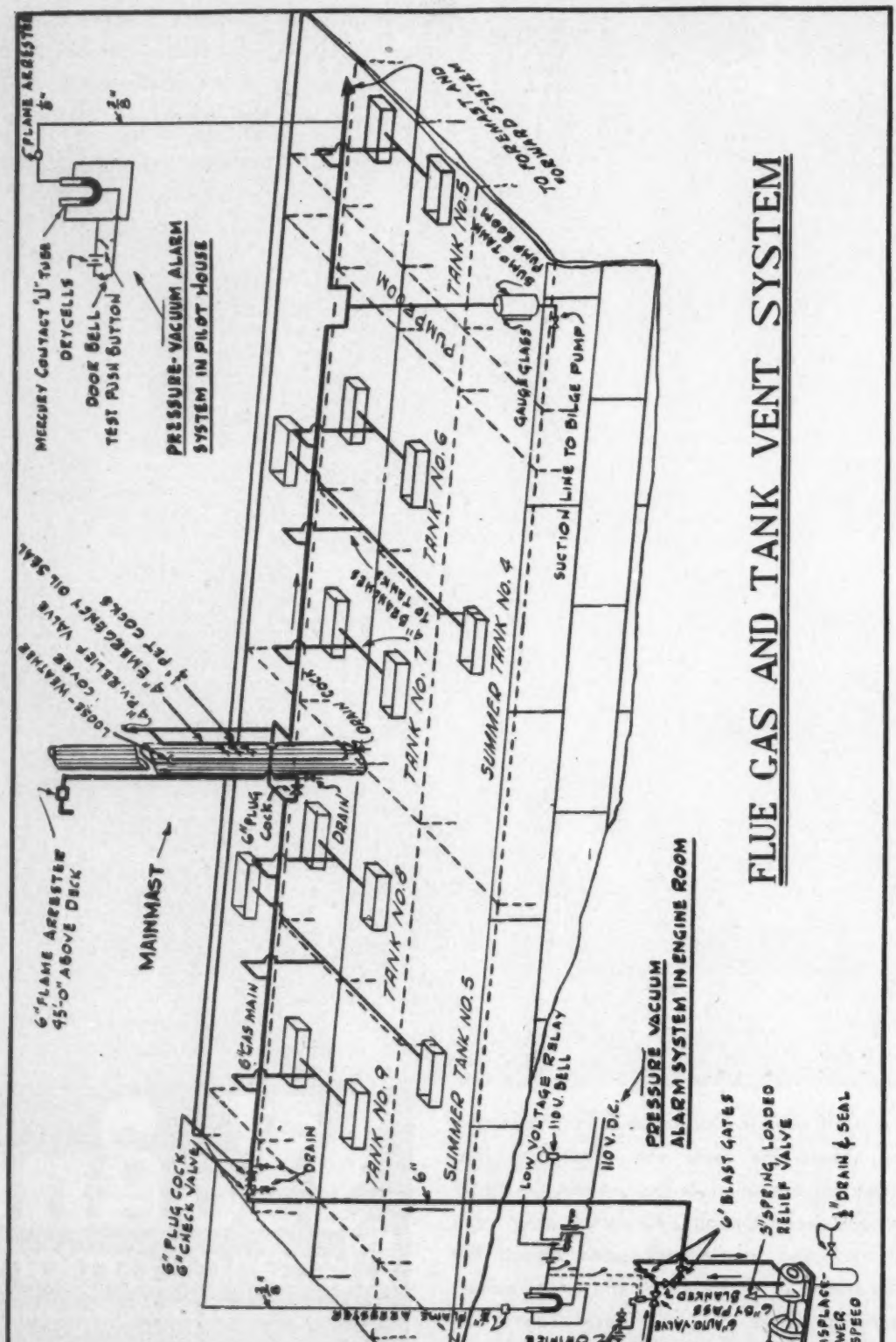

FIGURE 5

may we offer a suggestion for 1931?

Here is a suggestion for 1931 based on the experience of scores of shippers, large and small, in 1930.

Thruout the year these shippers had the full use of tank, refrigerator and Palace live poultry cars of very latest design. They were able to add to or subtract from their supply as requirements dictated, but paid only for the facilities they used. They exercised the advantages of car ownership, yet had no huge sums tied up in car equipment, no interest or taxes, no obsolescence charge-offs.

In addition, they had at their command the extensive bulk storage facilities maintained for their benefit at Chicago and Tulsa.

In view of the satisfaction received by the shippers who used North American Leasing Service in 1930, our suggestion is to investigate these facilities in connection with your 1931 plans.

Car Shops:
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North American Car CORPORATION
Executive Offices: CHICAGO, ILL.

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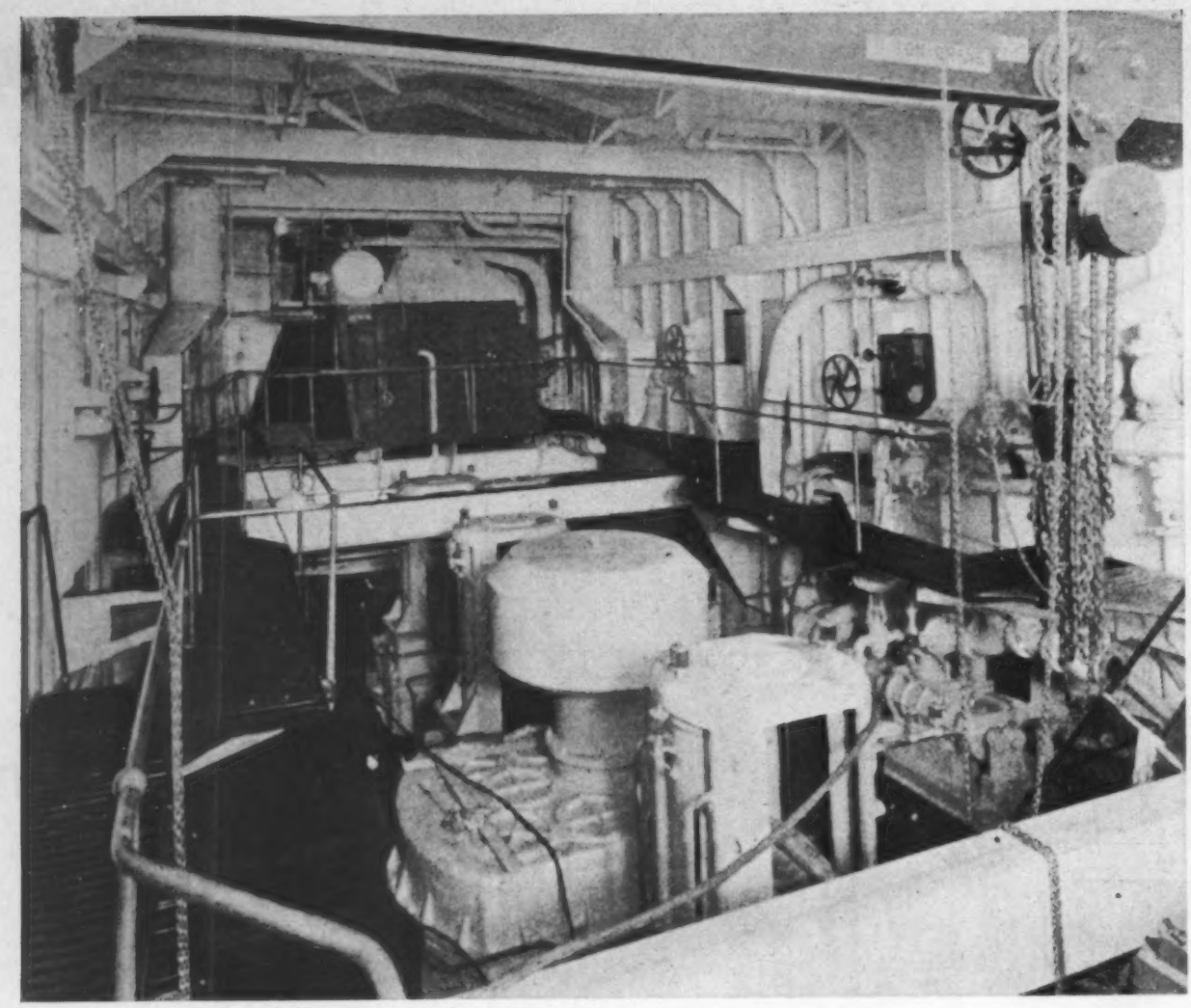


FIGURE 6— *Flue Gas System Engine Room, Sun Tankers*

this cause, as well as the ever-present chance of explosions on starting up or shutting down. Steaming of tanks sets up temperature stresses that the tanks are not designed to stand, resulting in many leaks at joints and rivets, which would not occur if flue gas were used. From an economical standpoint alone, the advantage of the use of flue gas as compared to steam is obvious.

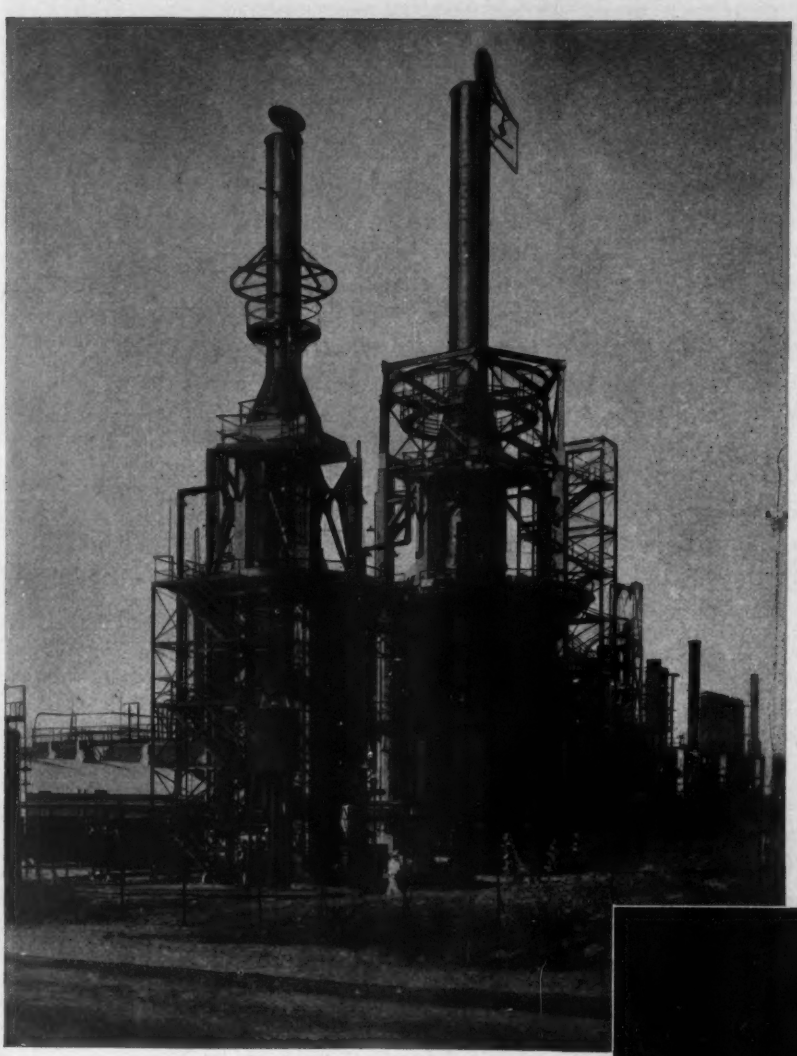
Miscellaneous uses of the flue-gas system, which have proved advantageous and economical, are to replace steam as a smothering agent in enclosed high-pressure exchangers, pipe still header boxes, and closed trenches. We have such installations operating successfully, and plan an extensive installation during the ensuing year. The amount of steam used for such purposes at present is an appreciable expense item.

Figure 2 and 3 show purgers installed by our company on gas holders. Figure 4 shows a vertical generator designed for limited spaces and connected to a battery of large fractionating towers and stills. The blower equipment is in the small brick box. Appendix "A" gives a typical set of instructions for purging gas holders. Appendix "C" gives instructions for a fractionating tower.

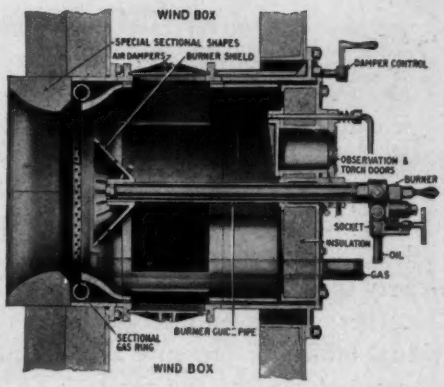
TANKER SYSTEMS

As tank ships are a part of refinery equipment in many instances, a description of such installations is of interest. Standard Oil Company of California has done a great amount of work in the development of flue gas systems on steam-driven tankers, and has published complete data.

Sun Oil Company, operating practically all Diesel tankers, has developed and installed on most of its ships a somewhat similar system, modified for Diesel engine use. Figure 5 shows diagrammatically the Diesel tanker system. Appendix "B" is a typical instruction sheet issued to ships covering operation of the flue gas system. The generator system is the same type as shown in Figure 1, with such modifications in arrangement as are required to meet space limitations. Figure 6 shows a typical arrangement in one of the Diesel tankers. The blower is at the extreme right-hand side, the wash tank is in the background and the generator is behind the boiler in the center background. The arrangement provides



. . . a register with experience . . back of it's . . advanced . . . . features . .



Sectional view of the Square Type C Register showing burner and gas ring.

Plant of the Gulf Refining Company at Fort Worth, Texas, uses two separate types of Coen Register installation. Lower view shows the one-register one-burner installation, firing a De Florez type High Pressure Still vertically.

COEN TYPE C

is not a new and unproven Register but a development backed by over fifteen years of service in the mechanical burner field. It represents the ultimate in register efficiency.

Designed for stills and boilers, forced, or natural, or induced draft, the Type C Register provides for complete frontal insulation as well as increased capacity, with less air pressure. Used in conjunction with the Coen Burner, with either gas or oil for fuel, the Register is designed to give a rotary motion to the air necessary for combustion without the use of air-directing vanes.

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for the flue gas to be taken either from the boiler or the small generator. The boiler, when in port, is always run for the steam auxiliaries, and supplies the large amount of flue gas required to keep the oil tanks full of gas while pumping out. The generator is used when at sea to keep the tanks full of gas, replacing any loss by breathing. The tanks at all times are free of air. This is accomplished by having the tanks filled with flue gas before loading is started and by supplying flue gas to replace oil when pumping out. Connections also supply flue gas to the cofferdams, which have been found normally to have an explosive atmosphere due to small leaks and no circulation.

To use the system effectively, certain changes in conventional ship design are necessary. No ullage holes are used in hatches, the tanks being gaged through eight inch standpipes. Correction for levels thus noted due to tank pressure is made by manometer readings. Six-inch eye ports with wipers are fitted in hatches for use in topping off tanks. An enamelled scale and copper float secured to hatch trunk may thus be watched, and exact oil level noted. No breather valves or flue gas valves are fitted to individual tanks, all pressure and vacuum protection being concentrated at the masts. Each mast relief is capable of protecting the entire vessel. This relief consists of an oil seal with blow-off cover and an especially designed breather valve. A flame arrester is located at the mast outlet 45 feet from the deck. An emergency pressure relief device, for use in topping off, consists in a weighted ullage cover on each eight inch standpipe. This is dogged down at sea when the protection is not required. A continuous drainage system at the low points of the gas lines eliminates difficulty with condensation, the drainage being carried to a small tank in the pump room. Control devices consist of a carbon dioxide indicator, an automatic shut-off valve, and pressure-vacuum alarms.

The flue gas system cannot be used in the pump room, as men must work there. This room is protected by an exhaust duct ventilating system operated by a blower located on deck. In case of fire in the pump room, a system of nine bottles of carbon dioxide is provided. The pull cord is located at the after bridge rail. In the event the carbon dioxide system is used, the pull cord also shuts off the ventilating system, thus allowing the carbon dioxide to smother the fire. Lighting of the pump room is effected by powerful lights located on deck, shining through dead lights. This removes all electrical wiring from the pump room, the pumps being steam turbine-driven centrifugals or of the reciprocating type.

The cost of a flue gas system for a 13,000-ton tanker, including the additional safeguards described, is approximately $10,000 installed.

The cost of a flue gas generator for refinery use, as shown in Figure 1, is approximately $1,500, installation costs varying according to conditions.

Summing up, it has been demonstrated by results obtained on actual installations that the presence of explosive mixtures of oil vapors and air may be eliminated by three practical and economical methods. One of the three methods consists in the use of gas as an enrichment agent and as the displacement medium in tank breathing, eliminating the presence of air. The second, and least used method, consists in forced circulation of air through tanks containing small percentages of dissolved gas in heavy oils, to prevent the tank atmosphere exceeding the lower explosive limit. The third, and most widely applicable method, consists in the generation of flue gas and its use to purge air or oil vapors from various types of refinery equipment, including tank ships and barges.

In conclusion, the data given in this discussion are based upon our experience, and many specific details are necessarily lacking—due to the great variety of the applications; but it is hoped that the general descriptions, drawings, and instruction sheets will be of some general interest. Details are available to anyone in the industry who desires them, in conformity with the policy that anything contributing to the removal of hazard to life and property in refineries should be made the property of the industry.

APPENDIX A

Instructions for Operating Purges for Pressure Gas Holders

I. GENERAL INSTRUCTIONS.

1. The purpose of the purger is to prevent explosions and fires. Tanks that are filled with flue gas are non-explosive, but the oil gas issuing from such tanks may be *inflammable*, or may burn like a torch in the open air. If gas should be ignited by lightning at top of vent line while purging gas holder, the flame could not travel past flame arrester down the 4 in. pipe, and fire could be put out by closing 4 in. valve.
2. Although tanks are non-explosive when purger is operated properly, all unusual fire precautions are to be taken to guard against mistakes and unforseen conditions.
3. No man shall enter a tank filled with flue gas without special authorization from the superintendent in charge. A man wearing a gas mask supplied with air from a blower can safely enter such a tank. Men entering tanks filled with either oil vapor or flue gas should be equipped with life lines to helpers outside.
4. Flue gas *will not* supply enough *oxygen for respiration*, and may contain some poisonous carbon monoxide. A man may *faint* suddenly due to lack of oxygen with little or *no previous discomfort*. Suffocation (lack of oxygen) is more apt to result from exposure to boiler flue gas than is poisoning by carbon monoxide. The chemical laboratory has a simple and reliable device for quickly detecting the presence of carbon monoxide.
5. Anyone overcome by breathing oil vapors or flue gas should be given immediate first aid treatment, using the Schaeffer prone pressure method of artificial respiration.

II. TO OPERATE PURGER.

1. Open 2 in. blow-off valve near gas holder to waste flue gas to air while starting. See that air inlet blank flange is bolted on.
2. Open cooler water valve and see that water runs to sewer from drain.
3. Fill water seal tank to about 12 in. in gage glass. Leave drain and supply valves cracked. Drain blower bed plate, *and be sure to close drain valve.*
4. See that valve in flue gas line at gas ball is closed. Remove blank flange in this line, if fitted.
5. Lubricate blower and motor bearings, using 300 viscosity oil. Start blower and throttle down on 2 in. blow-off until relief valve lifts. This will reduce draft at burner and facilitate lighting.
6. Start burner. Use gas if available; otherwise use mechanical atomicing oil burner with furnace oil.
   a. If gas is used, run blower on air for a few minutes before lighting, to clear furnace of gas. Insert lighting torch through the air register before opening gas master valve. Stand well clear of furnace from openings when applying torch.
   (NOTE—Gas regulating valve has a small hole drilled through disc to facilitate regulation and prevent shutting off gas by mistake. Both master and root gas valves should, therefore,

Billions of Bubbles

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WHEN a 30,000-gallon gasoline plant, built to stay put, can be disassembled, moved 28 miles, re-erected, and put back in operation—all within a period of less than 30 days, — it would seem that the non-portable had taken on portability.

Such was the case with the plant here pictured. Originally built in the Long Beach field, this plant was operated nine months. Then, after being shut down three months on account of a drop-off in gas, it was sold (bringing the seller a nice operating profit) and moved to its present location, where it is producing 120% of its rated capacity of finished gasoline.

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be closed when shutting down, as regulating valve cannot be made tight.)

b. Regulate air opening in gas burner register, or oil burner air butterfly valve, and adjust gas or oil valve to give a slight haze at gas outlet. Have chemist test flue gas. There should be *no* carbon monoxide, and the composition of the other two gases should lie between the following limits:

CO_2 — 9 to 13 per cent O_2 — 2 to 6 per cent

If at any time the carbon dioxide content falls below 8 per cent or the oxygen content rises above 10 per cent, notify the superintendent in charge.

7. While operating: Maintain level of water in seal visible in gage glass. Keep motor and blower bearings properly lubricated. If no stuffing boxes are fitted, be sure blower oil holes are kept plugged to prevent leakage of air and oil into blower casing around shafts. Watch cooler sump to be sure cooler drain is open.

8. Have flue gas tested every hour by chemists. Do not change burner fuel or air setting after starting to purge holder, unless so directed by chemist.

III. To PURGE HOLDER WITH FLUE GAS.

1. Drain gas ball and calibrate gas pressure gages.

2. Secure 4 in. flame arrester to 4 ft. length of 4 in. pipe and screw pipe into 4 in. valve on top of gas holder.

3. Run down gas pressure to 15 lb. by using gas in plant, and shut off burner system. Open 4 in. valve on top of holder and blow gas to air until pressure gage shows 2 lb. pressure on holder. Insert blank in 8 in. line at valve near holder, using non-sparking tools.

4. Start purge as above.

5. Open flue gas valve at bottom of holder after closing 2 in. gas blow-off connection on line from blower, and before pressure on holder drops to zero. If purger should stop for any reason while purging, or while gas ball pressure gage shows 2 lb. or less, close 4 in. valve at top of holder to prevent drawing in air if holder should cool off.

6. Operate purger continuously, blowing out a mixture of oil gas and flue gas at top of holder. Have chemist test for carbon dioxide and oxygen content at top of holder every 2 hours. When sum of carbon dioxide and oxygen in escaping gas rises to the average found at purger outlet for previous 6 hours, and when carbon dioxide and oxygen contents of mixture leaving holder are satisfactory (see II-6), the holder can be considered as safe for opening, but *not* for entering. If there is only a manhole, safety valve or similar repair to make, it will not be necessary to sweep holder with fresh air.

IV. To SWEEP HOLDER WITH FRESH AIR.

1. If men are to enter holder to inspect condition or do any inside work including welding, shut off furnace and remove blank flange over air screen on blower suction line. Shut off cooling water and drain out water seal tank and furnace jacket. Keep blower running and pump fresh air into holder continuously.

(NOTE.—If there is no hurry regarding entering gas holder, blower can be stopped and both manholes left open. As flue gas is slightly heavier than air, it will run out of bottom until chimney effect of holder reverses the direction of flow.)

2. If both manholes are left off, the chimney action of the gas holder will cause a constant circulation of fresh air, which can be supplemented by running the purger blower with the air inlet open.

3. Test air and flue gas issuing from top of gas holder, and when carbon dioxide falls below 2 per cent and oxygen rises above 17 per cent, men can enter without masks and perform all kinds of work, provided that the combustible gas indicator reads "SAFE" at 4 in. top outlet and at manholes when opened, and the carbon monoxide indicator shows no carbon dioxide.

4. While examining inside of ball, pay particular attention to thickness and distribution of sulfur accumulations over entire surface, and depth and extent of pitting in bottom of ball around drain hole, and report to Philadelphia office.

V. To SWEEP OUT AIR WITH FLUE GAS.

1. Before putting a gas holder which is filled with air into service, it is necessary first to sweep out all air with flue gas.

2. Start purger and blow flue gas to air. When chemist finds carbon dioxide content of flue gas satisfactory (see II-6 above), turn flue gas into holder and replace manhole plates, allowing gas and air to blow out through 4 in. flame arrester at top of holder.

3. When quality of flue gas mixture coming out of holder is satisfactory (see II-6 above), and when all is ready to admit oil gas, close flue gas inlet valve and open 8 in. oil gas valve after removing blank flange. When oil gas coming from top of ball shows not over 3 per cent carbon dioxide and is, therefore, suitable for combustion in furnaces (although diluted with flue gas and, therefore, leaner than the ordinary plant stripped gas), close top outlet valve and remove the 4 in. stack and flame arrester.

VI. AFTER EACH COMPLETE CYCLE OF OPERATIONS.

1. Thoroughly clain and lubricate the entire system including the oil burner, and drain out water seal tank and water jacket on furnace to prevent freezing. Clean gage glass on water seal tank.

a. Blower. Remove top pipe plate and examine interior for corrosion or soot accumulation. Remove plugs from bearings and examine oil. If contaminated with soot which has worked in around shafts, flush out and replace with 300 viscosity oil.

(NOTE.—There is no danger of this occurring on four stuffing box machines.)

Repack gland, if necessary, using braided asbestos packing. Remove drain valve, and see that drain in bed plate is open and bed plate dry.

b. Cooler. Remove 8 in. manholes and plugs in pans. If found clogged, flush out with fire stream. If inside is badly corroded. remove tile from lower section and paint entire inside of cooler with a good hot water and moist air resisting paint.

c. Check valve. Take off cover after every operation, examine seat and disc, and clean out any accumulation of soot.

2. Operator in charge must certify in writing to plant superintendent that above work has been completed and purger is ready for immediate use.

APPENDIX B

Instructions for Operating Flue Gas Systems on Oil Tankers

I. GENERAL INSTRUCTIONS.

1. The purpose of the flue gas and tank vent system is to prevent explosions and fires. Tanks that are filled with flue gas are non-explosive, but the gas issuing from such tanks may be *inflammable*, or may burn like a torch in the open air. If oil vapor should be ignited by lightning at top of mast vent line while loading, the flame could not travel past flame arrester down the 6 in. pipe, and fire could be put out by closing 6 in. mast valve.

2. Although tanks are non-explosive when flue gas system is operated properly, all usual fire precautions are to be taken to guard against mistakes and unforseen conditions.

3. A 4 in. oil seal emergency vent pipe is installed at each mast directly connected to the 6 in. deck main. Oil will blow out before pressure or vacuum in tank reaches 2½ lb. per sq. in. The weather hood provided at top of seal would be blown clear in case of a rush of oil from 4 in. pipe. Petcocks are provided for use in checking oil level, and a drain is installed at bottom of bend to permit removal of any water which might enter. The petcocks should not be used when there is a pressure or vacuum on deck system. A 4 in. pressure-vacuum valve with non-corrodible seats, springs, and discs is installed on top of each 4 in. oil seal, set to release at 2½ lb. per sq. in. vacuum or pressure.

4. Alarm "U" tubes are placed in pilot house and engine room, filled with mercury and marked in pounds to permit men on on watch to read pressure or vacuum on 6 in. vapor main. When 6 in. mast valves are open after loading is completed, the mercury columns should both stand at zero, and their height can be adjusted by adding mercury at top of open leg, or by draining out mercury at bottom.

5. No man shall enter a tank filled with flue gas without special authorization from the captain. A man wearing a gas mask supplied with air from a blower on deck can safely enter such a tank. Men entering tanks filled with either oil vapor or flue gas should be equipped with life lines to helpers on deck.

6. Flue gas *will not* supply enough *oxygen for respiration*, and may contain some poisonous carbon monoxide. A man may *faint* suddenly due to lack of oxygen with little or *no previous discomfort*. Suffocation (lack of oxygen) is more apt to result from exposure to boiler flue gas than is poisoning by carbon monoxide.

7. Anyone overcome by breathing oil vapors or flue gas should be given immediate first aid treatment, using the Schaeffer prone pressure method of artificial respiration.

II. LOADING CARGO OR BALLAST.

Engine Room.

1. See that automatic valve is closed and test alarm system using snap switch on gage board.

Deck.

1. Before entering port, drain all liquid from 6 in. main and pump out drain sump in pump room. Test pilot house alarm, using push button.

2. *Open both 6 in. mast valves* to permit free escape of gas from tanks. See that after 6 in. valve is closed.

3. After loading, when pilot house mercury "U" tube registers zero, check oil level in 4 in. seals at masts, and drain a small quantity of liquid out at bottom to see if water has collected in pipes. Oil level should stand between middle and top petcocks.

4. *After loading,* close both mast valves and drain out tank vent system.

III. TOPPING OFF.

1. All tanks are connected together by the vapor system, and pressure built up in one or more tanks due to loading is transmitted to nearby tanks. Only a slight pressure or vacuum can be measured as described below, using hand "U" tubes. All tank valves must, therefore, be throttled down or closed before final tank ullages are reached. After most of the valves have been closed and shore pumps have been slowed down, the pressure caused by loading will fall very low. Tanks should be loaded a few inches higher than ullage finally desired, to allow for air pockets under decks.

IV. GAGING CARGO OR BALLAST.

Eight-inch standpipes are provided for gaging all tanks. These are fitted with lead-weighted covers which will lift in case pressure in tanks should rise above 2½ lb. per sq. in. or in case of a bad spill. Pin back ullage cover and gage standpipe in usual manner. *Be sure to close ullage cover at once.* 10 in. hand "U" tubes are provided for use in correcting ullage to allow for a pressure or vacuum in tanks at time of gaging. A wire hook is provided for convenience in handing the hand "U" tube to the petcock on hatch trunk, leaving the hands free to hook the rubber tube to petcock and open the cock. Before use, "U" tubes should be filled to about mid-height with same oil as carried in the tanks to be gaged. If there is a pressure in the tank, oil in "U" tube will rise on side opposite to rubber tube. If there is a vacuum in the tank, oil will rise on same side as rubber tube. In case of *vacuum, subtract* inches between oil surfaces in hand "U" tube from ullage taken in standpipe. In case of *pressure, add* inches between oil surfaces in hand "U" tube to ullage measured in standpipe. Arrows and labels are placed on "U" tubes to avoid confusion. Secure covers with hook bolts after gaging.

V. SUNOCO SPIRITS.

1. After loading spirits, insert blanks in 4 in. gas branches. This will prevent contamination by gasoline vapor from other tanks while loading gasoline, or when under way.

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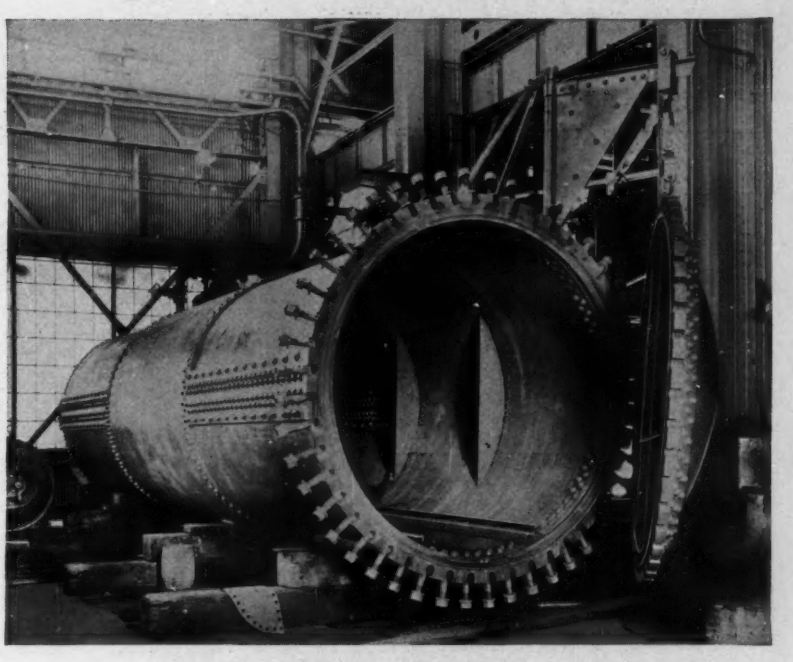
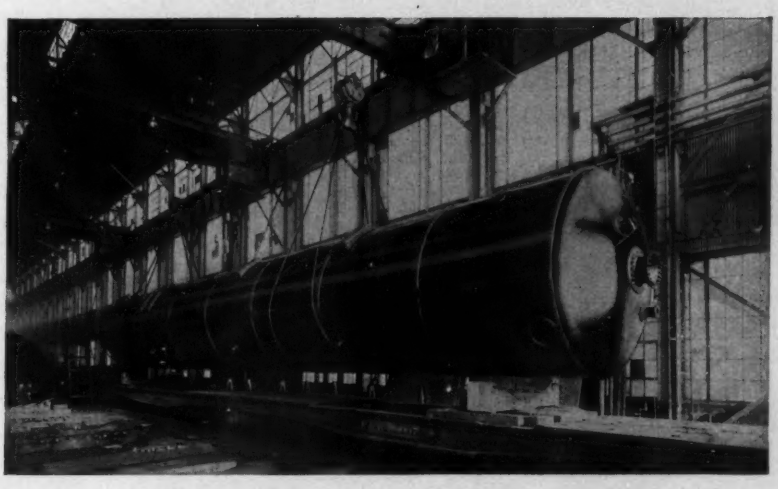


IMPREGNATOR SHELL



TOWER—13′ 4″ DIAMETER x 95′ HIGH—WEIGHT 250,000 LBS.
HANDLED AND SHIPPED IN ONE PIECE

SUN SHIPBUILDING & DRY DOCK CO., Chester, Pa.

2. Before pumping out spirits: Before removing blanks in vapor branches, start flue gas blower and open 6 in. valve at foremast to sweep all gasoline vapor out of 6 in. main.
3. Be sure to remove blanks before starting to pump out spirits, to avoid drawing in air at tank breather valves.

VI. PUMPING CARGO OR BALLAST.

Engine Room.

1. Turn on cooler water and lift automatic valve. Test valve by turning off water. Snap on alarm switch in automatic valve circuit. Be sure there is at least 20 lb. pressure on water gage. Whenever possible, use centrifugal sanitary pump to avoid pressure fluctuations. If plunger pump is used, throttle line to valve to avoid excessive pulsations which may cause catch to trip while there is still sufficient average pressure on cooler.
2. Open blast gate to furnace used to supply flue gas.
3. Open 6 in. gates in blower inlet and outlet. See that ½ in. blower drain line trap is filled with water to avoid drawing in air while starting up.
4. See that magnetic brake releases properly. Engineer or fireman on watch should adjust blower speed as necessary to maintain ½ to 2 lb. pressure on deck system at all times after pumps have actually been started.
5. As soon as gas pressure on gage board rises above ½ lb., connect wire on "U" tube to left-hand binding post. This will cause alarm to ring if pressure should fall below ½ lb. per sq. in. Test alarm system by pressing push button.
6. *Every hour* take a gas sample at connection on blower outlet line and read carbon dioxide contents, using Hayes instrument supplied. By good firing, the carbon dioxide content of flue gas can be held above 11 per cent without making excessive smoke —Report to chief engineer if reading falls below 9 per cent.
7. If blower is ever down for repairs, remove blank from blower by-pass and close blower inlet and outlet gates to permit gas to be drawn into tanks by vacuum caused by falling oil level. Leave ½ lb. connection on alarm "U" tube disconnected. As blast gates leak, they should not be depended on for air tightness; and blanks should be used where necessary while working on blower.
8. Draining tanks. When requested by deck, slow down blower to reduce gas pressure on tanks.
9. When notified by deck to shut down, stop blower, close blast gate at furnace, snap off switch to break alarm circuit to automatic valve, and turn off cooler water. See that automatic valve drops at about 12 lb. water pressure. Test alarm using automatic valve snap switch on gage board.

Deck.

1. When nearing port, drain vapor lines, check oil seal drains for water, and check height of oil in seals.
2. Be sure the 6 in. main-mast valve is closed (with handle or lugs on stem pointing across pipe). Open after 6 in. valve and crack foremost valve.
3. Fifteen minutes before starting pumps, send word to engine room to sart pumping flue gas slowly. When oil level falls several feet below deck, close foremast valve and notify engine room to speed up blower. While there is gas pressure on system, examine the 6 in. expansion joints in deck main for leaks.
4. Draining tanks. Open foremast valve to relieve excess of gas. Tell engine room to run blower at low speed. Open standpipe cover and examine oil level whenever desired. *Do not leave covers open longer than necessary.* The mist in standpipe due to moisture in flue gas will quickly disappear, and ship's bottom can be seen. When bottom is dry, listen for breaking suction. If necessary to open hatches for any purpose, and for inspection, close cover as soon as possible to avoid admitting air to tank.
5. Notify engine room when pumping has been completed, so that flue gas system can be shut down. Close after 6 in. valve and drain out the vapor system. Close foremast valve to seal tanks from air.

VII. IF ALARM SIGNAL SOUNDS.

1. See if alarm is caused by too much or too little pressure (vacuum) in tanks. If alarm circuit is out of order, disconnect battery and look for grounds.
2. *Unless cause for excessive pressure or vacuum can be remedied at once, open 6 in. mast valves.* Close valves as soon as condition is remedied. Break alarm circuit while looking for trouble.
3. *Low pressure vacuum alarm while pumping cargo or ballast.*
   a. Automatic valve may be closed due to failure of cooling water, melting of fusible link, or valve being out of order. If cooler water gage reads over 20 lb., and cooler gas and drain outlets are cool, block automatic valve open until repairs can be made.
   b. Gas valve to furnace may be closed.
   c. Check valve may be stuck, or cooler or gas pipes clogged up.
   d. Blower speed too low—try high speed.
4. High pressure alarm while pumping out.
   a. If due to stopping or slowing up pumps, see that blower relief valve is properly adjusted, and slow down blower.
   b. Open foremast valve just enough to relieve pressure until pumps are started, if trouble continues.
5. High pressure alarm while loading.
   a. See that both mast valves are open. Examine drains, and probe any which do not blow out gas or liquid when opened.
   b. Examine internal grids and outlet screens of flame arresters at top of masts to see if they are clogged up.

VIII. STEAMING OUT.

Pin ullage covers back and insert sheet metal vent pipes with cowls facing away from wind, before turning on steam. Sixteen of these pipes and cowls are provided to carry vapors clear of deck while steaming out, or enough for about half of main and summer tanks. Blank vapor branches at main, and close all summer tank drop valves. As low pressure steam is lighter than the gas and oil vapors, it will fill up top of tank first and will then work downward, forcing out the gas through standpipes. The after 6 in. valve and both 6 in. mast valves should be closed while steaming out. When steam appears at cowl, the tank can be considered as hot and full of steam.

IX. SHIPYARD OVERHAUL NOTES.

Engine Room.

1. Make any repairs to motor, blower, or magnetic brakes which may be necessary. Remove blower top pipe plate, jack over blower by hand, and cleaned out any deposit which may have collected. Report any sign of corrosion to office. Repack blower stuffing boxes if necessary, using ⅜ in. diameter graphite impregnated braided asbestos packing. Examine blower roller bearings and motor bearings. Blow through ½ in. blower drain line with air to make sure it is clear. Close valve at lower end and test drain line for tightness. Remove screw and fill flexible coupling with light cup grease, using a grease gun.
2. Take manholes off cooler and scrape; wire brush, and paint interior with two coats of hot salt water resisting paint, obtained from shipyard. Report condition to office. Be sure eye ports and gaskets in top section are in good condition.
3. Remove plug from nipple near automatic valve and examine fusible link. Block valve open and clean out valve seat.
4. Renew dry cells in engine room alarm circuit. Unscrew ⅛ in. flame arrester near "U" tube, and see that holes are clear.
5. Take cover off check valve and examine brass disc, stem and seat. Insert wire through bowl drain to see that it is open.
6. See that blower shaft is held from turning by magnetic brake when current is off, and that brake releases promptly when motor is started.

Deck.

1. Remove inside cores (grids) of 6 in. flame arresters on masts, and blow out with air or steam if necessary. Be sure covers are securely bolted on flame arresters after assembly. See that the coarse mesh screens fitted over outlets are free of dirt and in good condition.
2. Probe gate valves or plugged tees in drains to 6 in. main with rod to make sure they are open.
3. Fill 4 in. oil seals above middle petcock, using 65 to 100 deg. F. oil. Be sure metal hoods are free to lift off, but not loose enough to blow off in wind. Examine brass chains securing hoods to masts. If necessary to repair drain cock at bottom of seal, empty seal and refill after repairs are completed.
4. Lubricate 6 in. plug cocks at masts using water and oil-resisting lubricant sticks supplied. Adjust gland bolts, if necessary, to see that plugs are free but not too loose.
5. Test both sides of all 4 in. pressure-vacuum valves, using 25 lb. spring balance provided. Remove pipe plug over vacuum valve disc to permit hooking spring balance to eye. Be sure to replace plug. Both valves should lift at 17⅝ lb. pull, which corresponds to 2½ lb. per sq. in. pressure or vacuum. Examine condition of valves and seats, and report any signs of corrosion to office.
6. Renew dry cells in pilot house alarm circuit. Unscrew ⅛ in. brass flame arrester at "U" tube, and see that holes are clear.

X. SPARE PARTS AND SUPPLIES.

Engine Room.

1. Cooler.
   1. Two glasses and four rubber gaskets for eyeports.
   2. Two fusible links for automatic valve.
2. Blower.
   1. One complete set of packing for all four stuffing boxes three-eighths inch in diameter graphite impregnated, braided asbestos, or equal.
3. Blower motor.
   1. One set main and commutating field coils.
   2. One set starter coil and resistor grids of each size and kind.
   3. One set of brushes, brush holders, and brush holder insulation, with three extra springs.
   4. One set of contacts and springs.
   5. One set of two-bearings linings.
4. Alarms.
   1. 1 lb. mercury for use in both engine room and pilot house alarm "U" tubes.
   2. Six dry cells for use in both alarm circuits.

Deck.

1. One box water and oil-resisting lubricant for 6 in. mast valves.
2. One 25 lb. spring balance with hook altered to reach eyes on 4 in. pressure-vacuum valve discs.
3. Four 10 in. hand "U" tubes for use in gaging tanks, complete with hooks and rubber tubes, engraved with P-V labels and arrows.
4. 20 gal. (2 complete charges) of seal oil (about 24 deg. A. P. I. and 65 Saybolt universal viscosity at 100 deg. F.) for 4 in. oil seals.
5. Six ¼ in. brass petcocks, one male end, replacements for hatch trunks and oil seals.

APPENDIX C

Instructions for Operating Flue Gas Systems on Towers

I. GENERAL INSTRUCTIONS.

1. The purpose of the purger is to prevent explosions and fires. Spaces that are filled with flue gas are non-explosive, but the oil gas issuing from such spaces may be *inflammable*, or may burn like a torch in the open air. If flue gas and oil vapor issuing from gas stack were ignited by lightning at top of stack while purging a tower and connected system, the flame could not travel down the stack, and fire could be put out by closing a valve in 6 in. gas line.
2. Although spaces are non-explosive when purger is operated properly, all usual fire precautions are to be taken to guard against mistakes and unforseen conditions.
3. No man shall enter a space filled with flue gas without special authorization from the superintendent in charge of plant. A man wearing a gas mask supplied with air from a blower can safely enter such a space. Men entering spaces filled with either oil vapor or flue gas should be equipped with life lines to helpers outside.
4. Flue gas *will not* supply enough *oxygen for respiration* and may contain some poisonous carbon monoxide. A man may *faint* suddenly due to lack of oxygen with little or *no previous discomfort*. Suffocation (lack of oxygen) is more apt to result

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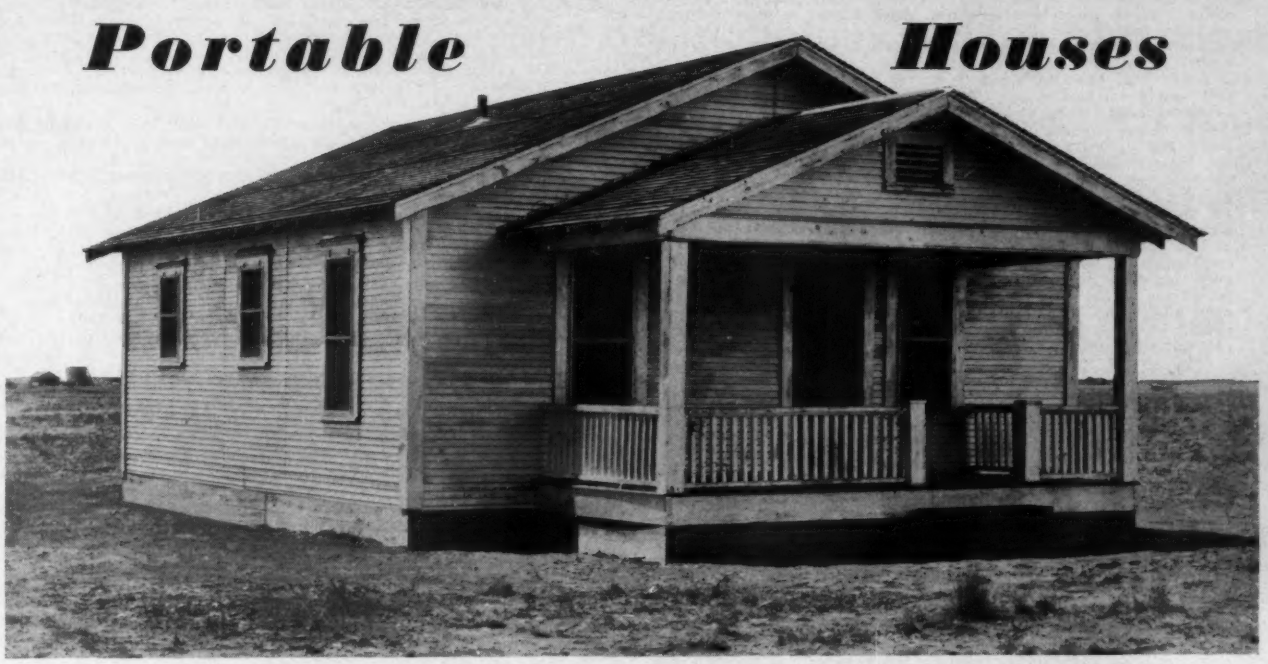

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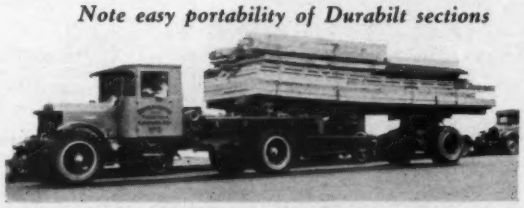

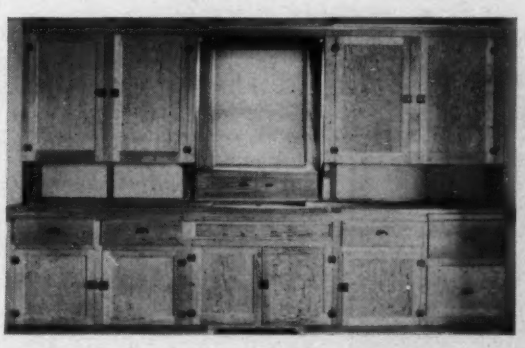

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from exposure to boiler flue gas than is poisoning by carbon monoxide. The chemical laboratory has a simple and reliable device for quickly detecting the presence of carbon monoxide.

5. Anyone overcome by breathing oil vapors or flue gas should be given immediate first aid treatment, using the Schaeffer prone pressure method of artificial respiration.

II. To Operate Purger.

1. Open 2 in. blow-off valve near tower to waste flue gas to air while starting. See that air inlet blank flange in blower house is bolted on.
2. Open cooler water valve and see that water runs to sewer from drain.
3. Fill water seal tank to about 1 ft. in gage glass. Leave drain and supply valves cracked. Drain blower bed plate and *be sure to close drain valve.*
4. Lubricate blower gears and bearings, and motor and oil burner, using 30© viscosity oil.
5. Start blower and throttle down on 2 in. blow-off until relief valve lifts. This will reduce draft at burner and facilitate lighting.
6. Start burner, using furnace oil for fuel. Close air space between burner nozzle and front plate with one turn of asbestos rope, and adjust air butterfly valve to permit all air required for combustion to be drawn in through the burner fan. Do not open butterfly wider than necessary. Adjust oil needle valve to give a slight haze at gas outlet. One and one-half turns open should be sufficient. Have chemist test flue gas. There should be *no* carbon monoxide, and the composition of the other two gases should lie between the following limits:

   CO_2 .....9 to 13 per cent
   O_2 .....2 to 8 per cent

7. While operating: Maintain level of water in seal visible in gage glass. Keep motor and blower bearings properly lubricated. Watch cooler sump to be sure cooler drain is open. Try drains in 3 in. gas line beyond seal tank to see that gas is dry.
8. Have flue gas tested every hour by chemist. Do not change burner fuel or air setting after starting to purge, unless so directed by chemist. If oxygen content should rise above 10 per cent or carbon dioxide fall below 8 per cent, notify superintendent in charge.
9. Gage oil tank every two hours, and report fuel consumption and fuel needle valve and air butterfly setting used to the Philadelphia office. Eleven per cent carbon dioxide will be high enough, and about 3½ gallons of fuel should be burned per hour.

(Note.—When plant is piped up to burn gas, these instructions will be modified to include instructions for lighting gas burner. The few minor changes necessary to permit burning gas will be covered by a marked blueprint; they will be the same as used at gas ball purgers.)

III. To Clear System of Air Using Flue Gas Before Starting Up Unit.

1. Before starting up a tower, condenser, gas separator and piping system which is filled with air, it is first necessary to sweep out all air with flue gas. This avoids danger of having an explosive mixture of air and oil vapor in the system at any time while starting up If tower trays and seals have been flooded with water to displace oil (see VI), water must be remove by hand before tower is closed.
2. Operate purger as above, pumping flue gas into bottom of tower, and sweeping out air via vapor lines, condensers, gas separators, and gas lines to stack.
3. Every two hours have chemist test mixture blowing out of petcock at gas stack. When the sum of carbon dioxide and oxygen issuing from systems is approximately equal to the average sum obtained at purger outlet during the previous 6 hours, and when the actual percentages ot carbon dioxide and oxygen leaving tne system are satisfactory (see II-6 above), the unit can be started up with safety.
4. Close valve in gas line to stack and shut off purger inlet to tower, to hold flue gas in tower until unit is actually running.

IV. To Break Vacuum in Unit When Shutting Down, Using Flue Gas.

1. Start purger (see II above) at least one hour before scheduled time to shut down. When chemist's test shows that flue gas is satisfactory, and when purger is properly warmed up and is delivering dry gas without soot, unit can be shut down.
2. After oil has been cut out of pipe still, and pressure on tower has been relieved, remove plug from tee on 3 in. tower inlet line, crack gate valve, and probe with ¼ in. rod to make sure gas inlet line to tower is not plugged. Stand clear of opening while probing to avoid accident in case tower is under a slight pressure at bottom.
3. Close 2 in. blow-off valve and open 3 in. flue gas valve to start gas into tower. Open necessary valves to permit flue gas to pass from top of tower through vapor lines, condensers, and gas separators to gas stack.
4. If no flue gas blows out at gas stack, there is probably a vacuum on tower, formed due to tower cooling down faster than blower can supply flue gas. If this happens, close valve in 6 in. gas line to stack and permit a slight vacuum to build up on system. This will increase flue gas blower delivery, and may require change of burner oil and air settings. Keep a record of vacuum formed, using water or mercury in 10 in. manometer.
5. Every two hours have chemist test mixture of flue gas and oil vapor leaving gas line at stack. When sum of carbon dioxide and oxygen content at stack is approximately equal to average for past 6 hours at blower, and when carbon dioxide and oxygen content is satisfactory (see II-6 above), the tower can be considered as safe for admitting air, provided that temperature in tower is below the closed cup flash point of the lightest oil present.
6. Keep purger operating until tower has cooled down, at which time it will be safe to open tower or any part of system. Tower will *not* be safe for men to enter without gas masks until flue gas has been swept out with air (see VI below.)

V. Emergency Shut-down.

If necessary to shut down in an emergency, and if purger cannot be started in time to prevent a vacuum forming in tower, turn steam into tower and keep steam on until flue gas purger has been running ½ hour, and gas quality has been approved by chemist, when steam can be turned off and flue gas turned into tower as above. It should be remembered that to turn steam into the tower means loss of time and labor to clear tower of water later. Therefore, whenever possible, avoid turning steam into tower and have purger ready to turn into tower by the time oil is cut out of pipe still.

VI. To Sweep Tower with Fresh Air.

1. If men are to enter tower to inspect conditions or do any inside work including welding, oil on pans and in seals must first be displaced, using clean water supplied by reflux pump.
2. Shut off flue gas furnace and remove blank flange over air screen on blower suction line in house. Shut off cooling water and drain out water seal tank and furnace jacket. Keep blower running and pump fresh air into tower continuously, exhausting air at gas stack or at any other desired point in system.
3. Test air and flue gas issuing from system, and when carbon dioxide falls below 2 per cent and oxygen rises above 17 per cent, men can enter tower without masks and perform all kinds of work, provided that the combustible gas indicator reads "SAFE" at outlet, and the iodine pentoxide indicator shows no carbon monoxide.
4. Clean up generous area near parts to be welded, using hand scrapers and rags. Keep blower operating to supply fresh air to tower while men are working inside, or use a larger capacity portable ventilation fan with canvas duct led through manhole.
5. Make frequent tests with combustible gas indicator to make sure that heat of welding does not vaporize oil and cause an explosive mixture to form.

VII. After Each Complete Cycle of Operations.

1. Thoroughly clean and lubricate the entire system including oil burner, and drain out water seal tank, water jacket on furnace and low point in water supply line under walkway to prevent freezing. Leave Leslie strainer valve open. Clean gage glass on water seal tank.
   a. Blower. Remove top pipe plate and examine interior for corrosion or soot accumulation. Lubricate motor bearings and blower bearings, and gears and Ray burner, using 300 viscosity oil. Repack gland, if necessary, using braided asbestos packing, 5 rings, ⅜ in. diameter, shaft 1½ in. See that drain nipple in bed plate is clear, and drain out bed plate.
   b. Cooler. Remove 8 in. manholes, and plugs in pans. If found clogged, flush out with fire stream. If inside is badly corroded, remove tile from lower section and paint entire inside of cooler with hot water and moist air-resisting paint. Replace tile in lower section only.
   c. Check valve. Take off cover after every operation, examine seat and disc, and clean out any accumulation of soot.
2. Operator in charge must certify in writing to superintendent that above work has been completed and purger is ready for immediate use.

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By THOMAS T. GILL

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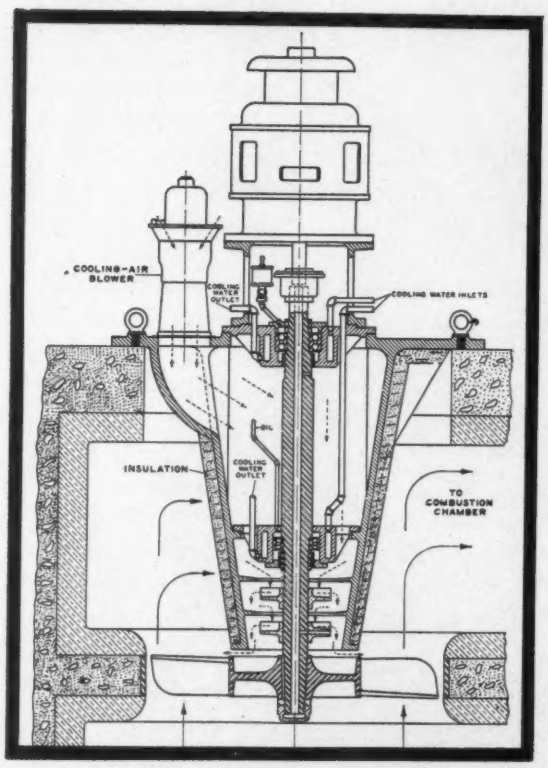

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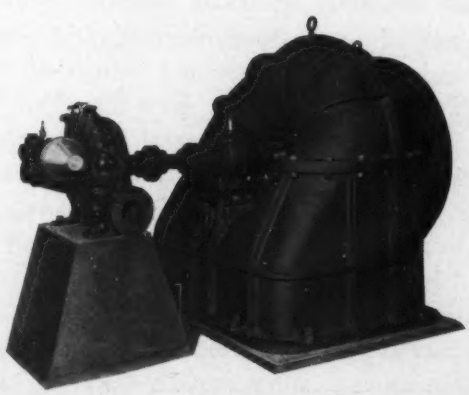

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Natural Gas Displacing Important Fuel Oil Outlets

By H. J. STRUTH
Staff Economist

A FACTOR of growing importunity to the refining industry's fuel oil market is the advent of more widespread utilization of natural gas. With long-distance pipe lines carrying natural gas into an ever-widening area of utilization, it is already apparent that the oil industry has lost a substantial part of its gas and fuel oil business. In fact, signs on the horizon point to further losses of fuel oil outlets that will be brought about not only through the direct utilization of natural gas for fuel but also through the displacement of manufactured gas by the natural product. This has already become apparent with the passing of numerous manufactured gas plants in various sections of the country that formerly utilized gas oil for the manufacture of artificial gas.

Statistics of gas and fuel oil distribution for the year 1929, prepared by the U. S. Bureau of Mines, present some interesting sidelights on the declining use of gas and fuel oil among industries that have turned to the use of natural gas for their fuel requirements. These facts also show the extent to which the use of gas oil in the manufacture of artificial gas is being displaced by the widening facilities for the distribution and utilization of natural gas. While the official figures show that there was an increase in the total demand for gas and fuel oil during 1929, further analysis reveals a number of unfavorable aspects in the market for these petroleum products that prompts the refining industry to exploit other market possibilities as a means of offsetting the definite decline in demand that has manifested itself in the consumption statistics of a number of important industrial outlets.

DEMAND FOR GAS INCREASES

Particularly distressing to refiners is the sharp downward trend being prescribed by the demand for gas oil from manufactured gas plants. During a period of four years, beginning with 1926, the consumption of gas oil for this purpose has declined from 996,000,000 gallons to 843,000,000 gallons ending with the year 1929. This year, the writer estimates a further decline in this department of the gas and fuel oil market that will reduce the total demand therefrom to only 725,000,000 gallons. In terms of barrels, this means a total decline in five years of nearly 7,000,000 barrels.

During the year 1929, the demand for natural gas increased 22 per cent; marketed production reaching the stupendous figure of 1,917,693,000,000 cubic feet, compared with a total of 1,568,139,000,000 cubic feet during 1928. This unusual growth was attributed to the completion of several long-distance pipe line projects that placed natural gas at the disposal of a large number of industrial consumers, many of which turned to it in place of fuel oil. The effect of a more wide-spread availability of natural gas was not only felt in the loss of industrial outlets for fuel oil, but resulted also in the elimination of numerous manufactured gas plants that had formerly been important outlets for gas oil.

With natural gas distribution facilities undergoing further phenomenal expansion that is destined to embrace a constantly wider area for its utilization, refiners face the prospect of further displacement of both gas oil and fuel oil for some time to come. It is evident, therefore, that the industry will be obliged to take definite steps toward the promotion of new outlets for the volume that is otherwise being lost through its displacement by natural gas. The situation in this regard is particularly acute on the Pacific Coast, where the availability of natural gas has made serious inroads upon the demand for gas and fuel oil. California gas and fuel oil consumption statistics for 1929 show that material declines were recorded in the use of this product by gas plants, smelters and mines, automotive industries, textiles and their products, logging and lumbering, cement and lime plants, ceramic industries, food industries and domestic heating. As a matter of fact, the records for 1929 show that natural gas has apparently displaced the outlet for gas and fuel oil in California, alone, to the extent of about 2,073,241 barrels. If we include to this figure the quantity of gas and fuel oil displaced by natural gas in the Rocky Mountain area, the Southwest, and certain industrial sections of the South Central and West Central states, the indicated total loss amounts to approximately 4,300,000 barrels.

Table 1 shows how the demand for gas and fuel oil was distributed to various classes of consumers during

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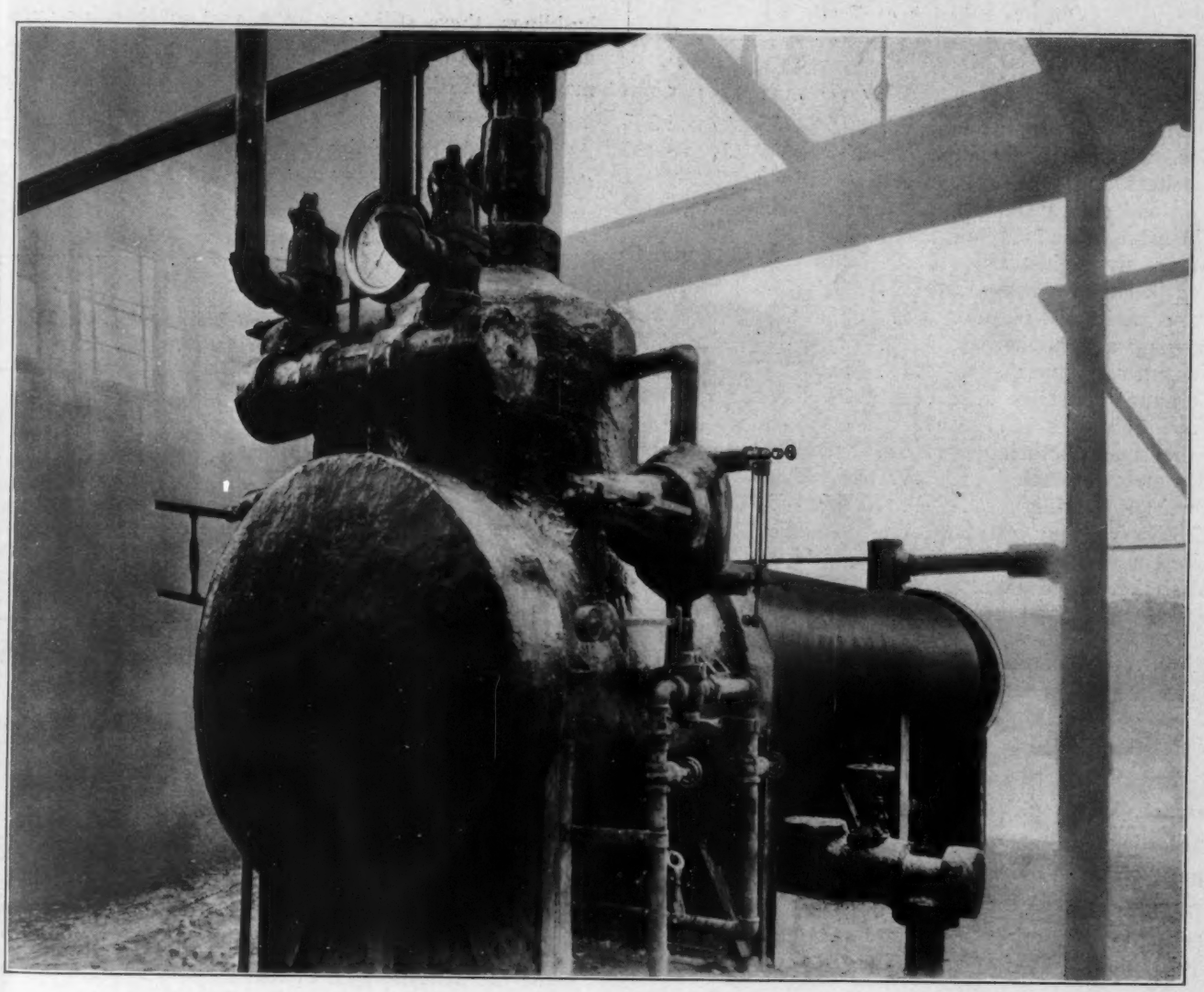

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the years 1929 and 1928. It was taken from the report of the Bureau of Mines entitled "National Survey of Fuel Oil Distribution, 1929," by E. B. Swanson.

TABLE 1
National Distribution of Gas Oil and Fuel Oil, 1928-1929
(Figures in barrels of 42 gallons)

Uses	1928	1929
Railroads	70,680,111	75,965,760
Steamships (including tankers)	89,942,155	92,042,365
Gas and electric power plants	30,901,657	31,478,020
Smelters and mines	6,897,642	7,049,965
Iron and steel products	19,429,514	20,318,526
Chemicals and allied industries	3,400,011	4,191,852
Automotive industries	3,628,495	3,224,410
Textile and their products	4,586,306	4,721,481
Paper and wood pulp	2,792,752	2,992,800
Logging and lumbering	2,673,234	2,248,215
Cement and lime plants	5,223,887	3,301,046
Ceramic industries	2,995,531	2,376,046
Food industries	6,488,288	6,924,603
Other manufacturing	10,023,352	13,548,032
Commercial heating	16,427,105	17,692,851
Domestic heating	5,971,556	7,190,556
U.S.Navy, Army transports, etc.	8,368,577	6,392,336
Used as fuel by oil companies	50,044,106	56,206,214
Miscellaneous uses	12,757,596	11,719,583
Total domestic deliveries	353,231,875	369,584,661
Exports and other shipments	44,428,220	39,150,832
Total distribution	397,660,095	408,735,493

It will be noted from these facts that railroads, steamships, electric power plants, iron and steel products, miscellaneous manufacturing and commercial and domestic heating offer the most important existing outlets for both gas oil and fuel oil. While gas and electric power plants showed a gain in total consumption during 1929, further analysis shows that the gain was directly due to increased consumption of fuel oil by electric power plants. In fact, there was an actual gain in fuel oil demand from electric power plants of 2,953,207 barrels, while manufactured gas plants consumed 2,376,844 barrels less than during the preceding year. Following is a break-down of the figure shown for gas and electric power plants:

	1929	1928
Electric power plants	10,079,129	7,125,922
Manufactured gas plants	21,398,891	23,775,735
Total consumption	31,478,020	30,901,657

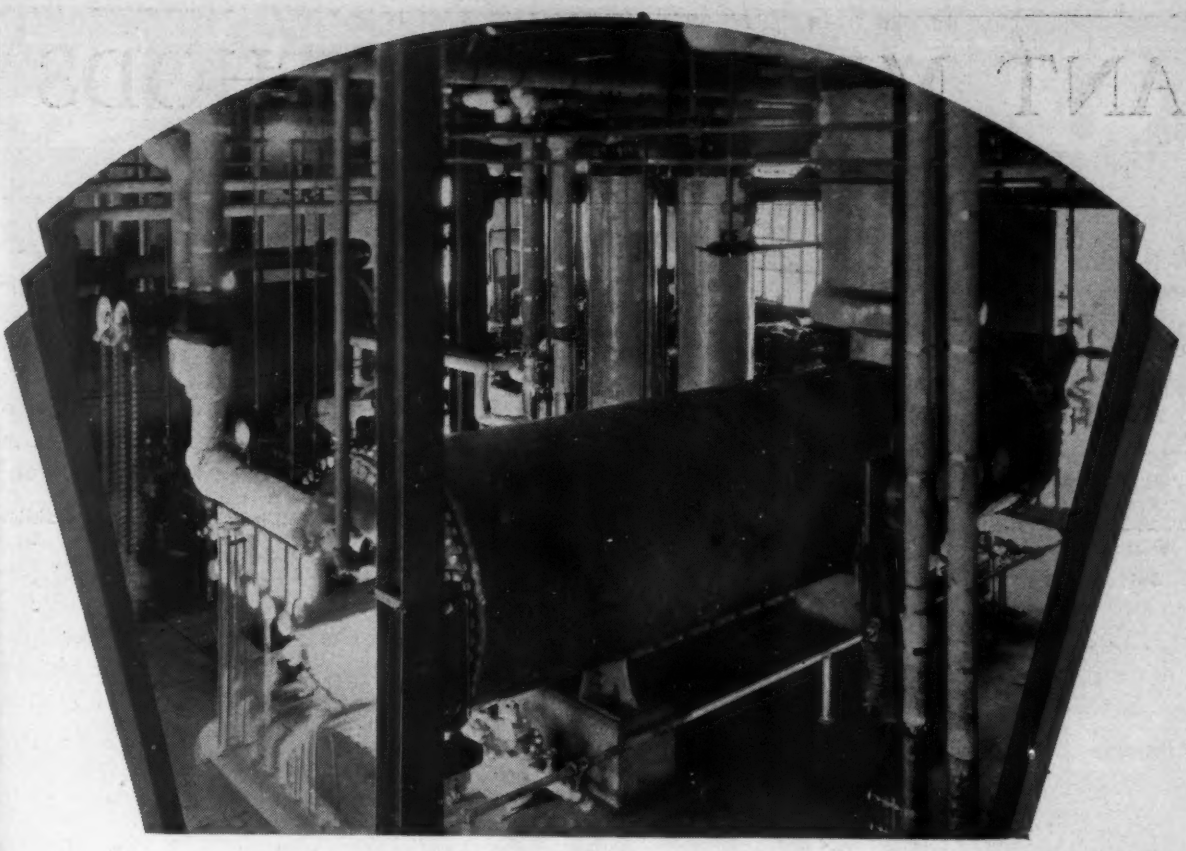
DOMESTIC DEMAND UP

One most encouraging factor in the gas and fuel oil market is the growing demand for oil for commercial and domestic heating. A record of domestic heating oil requirements from 1923 to 1929, inclusive, reveals that the demand from this one source has grown from 2,818,000 barrels to 17,640,000 barrels a year. It would appear, therefore, that the petroleum industry should encourage the more widespread adoption of oil heating by instructive advertising, in co-operation with the manufacturers of oil burners. Despite the fact that natural gas is being widely used for heating homes and buildings, there still remains a vast market for automatic oil heating equipment that spells an increased demand for distillates, gas oil and fuel oil. Especially is this indicated throughout the new England, Middle Atlantic and South Atlantic states. Table 2 shows how the demand for oil for heating was distributed in 1928 and 1929.

TABLE 2
Oil Consumed for Heating of Buildings, 1928-1929
(Figures in barrels of 42 gallons)

District	Commercial Heating		Domestic Heating	
	1928	1929	1928	1929
Pacific Coast	4,841,385	6,145,608	59,883	41,046
Rocky Mountain	18,329	40,116	79,585	101,032
North Central	2,438,316	2,378,286	2,706,930	3,326,792
South Central	1,813,722	1,595,563	383,234	411,779
New England	2,414,398	2,351,149	774,418	1,072,039
Middle Atlantic	4,802,723	5,048,737	1,878,352	2,180,361
South Atlantic	98,232	133,402	89,154	57,507
Total Gas Oil and Fuel Oil	16,427,105	17,692,851	5,971,556	7,190,556
Estimated Consumption of Lighter Oils	.....	.....	8,300,000	10,450,000
Total Consumption	16,427,105	17,692,851	14,271,556	17,640,556

Even though there was a gain in total demand for gas and fuel oil during 1929, the fact remains that a major portion of the increase was due to greater utilization of these products by the oil companies themselves, while the material gain in fuel oil consumption by railroads was prompted by the advent of unusually low prices. Of immediate concern to the refining industry is the definite displacement of gas and fuel oil by natural gas. The quantity of gas and fuel oil displaced last year represents the difference between a normal and an excessive stored supply of these products. Overproduction of gas and fuel oil has presented a serious problem to the industry this year, but under-consumption through the availability of increasing supplies of natural gas is a problem that can only be solved through realization of the need for new outlets and expansion of present outlets for this petroleum product. Refiners on the Pacific Coast have severely felt the keen edge of competition with natural gas fuel and lines now building or projected in other sections of the United States are expected to exact an additional toll in the form of decreased demand for gas and fuel oil.



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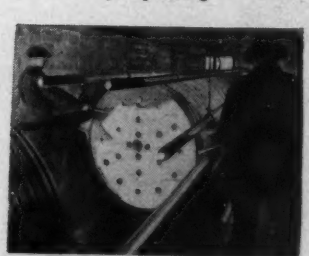

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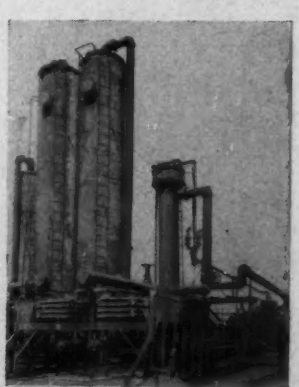

Carbondale Heat Exchanger installation.

PLANT MEN AND METHODS

By GEORGE REID

Specifications For Gasolines Discussion of gasoline specifications at the sessions of the Division of Refining, American Petroleum Institute, Chicago, last month, and Doctor Delbridge's pleas for a broad generic definition of gasoline, recalled by him after several years of silence on the subject, proved of much interest. There are many agencies concerned with gasoline specifications, with the Federal Specifications Board finally approving and designating what the Federal government wants for its motor driven equipment. Included in the agencies interested are: the Department of Commerce, Bureau of Mines, the Bureau of Standards, Committee D-2 on Petroleum Products and Lubricants of the American Society for Testing Materials, the Committee on Testing Methods and Specifications, Division of Refining, of the American Petroleum Institute and again, the Federal Specifications Board. Out of all this has come Motor Fuel F, Motor Fuel T, Motor Fuel V and United States government motor gasoline—and a 10-pound vapor pressure limitation. And state legislatures adopting Federal specifications in ignorance of climatic influences upon motor fuels and more often than not in ignorance of anything pertaining to motor fuels, specifications or otherwise. After a review of several state laws, and granting that the government has every right to make specifications for its own purchases, there is still every indication that Federal requirements exert too much influence upon gasoline marketing, and something could well be done about it. Perhaps Doctor Delbridge's suggested broad definition would be helpful.

First California Refinery Restored

Knock Testing Progress The development and perfection of the acoustimeter for use in measurement of detonation, and the final adoption of "octane number" instead of benzol equivalent promise to do much toward the early solution of problems surrounding the determination of measurement of knock in motor fuels. Certainly the standardization of engine, auxiliaries and method of procedure, is of much importance; but without a proper standard reference fuel and adequate automatons to eliminate the human element in testing (listening) it is doubtful if much in accuracy could ever be accomplished. Thanks to the acoustimeter (developed to a certain degree by the Association of Outboard Motor Manufacturers for the study of exhaust noises) the recording of sound intensity in chart form is possible, or its intensity may be indicated by a hand moving over a scale.

The reference fuel—a mixture of normal heptane with iso-octane—is tentatively agreed upon; and it is needed. The reference fuel is prepared by mixing different proportions of normal heptane with iso-octane until the knock intensity or detonation of the reference fuel exactly matches that of the fuel being tested. The rating of the fuel tested is then expressed as the percentage of iso-octane in normal heptane that is required to equal the tested fuel. In this work better accuracy can certainly be secured through the use of the indicating or recording acoustimeter. Incidentally, iso-octane can be synthetically prepared; but normal heptane is only obtainable from the Jeffry pine tree which grows rather isolatedly above the snow line of the California Sierra mountains. California Chemical Company, San Francisco, has agreed to furnish the industry 500 to 1000 gallons of pure normal heptane annually for test purposes, on a non-profit arrangement.

First Refinery Restored The first oil refinery in California, constructed in 1876 and located one-half mile southwest of Newhall, was dedicated Wednesday afternoon, November 5, following restoration to its original condition by Standard Oil Company of California. More than 200 pioneers and friends gathered to witness the unique exercises and the unveiling of a bronze tablet marking the plant as a memorial to D. G. Scofield and his associates of California Star Oil Works, predecessors of Standard Oil Company of California. The tablet was unveiled by Mrs. Rosamond B. Watson, grand-

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daughter of Scofield. L. B. Little presided at the exercises.

The first commercial oil production in the state was developed in Pico Canyon, a few miles west of Newhall, in 1875. After development of commercial production the old Newhall refinery was built, having had a charging capacity of about 300 barrels. The chief product was kerosene, with a little "benzine" and lubricating oil thrown in for good measure. Among the old-timers attending the unveiling were Clay M. Reynolds, who worked near the refinery in 1888; John Saunders, who worked in the district in 1882. J. H. Whitney,who worked in the Newhall field as early as 1879, and Fred Barington, who owned a hotel at Newhall during the early days of the refinery.

N. G. A. A. Program Committee A committee of four members has been selected to arrange the next annual convention of the Natural Gasoline Association of America. S. S. Smith, Shell Petroleum Corporation, is chairman, and E. W. Zublin, Texas Pacific Coal & Oil Company, G. P. Bunn, Phillips Petroleum Company, and W. W. Robinson, The Texas Company of California, are committeemen. The association meets each year at Tulsa, and the coming annual convention will be held during the third week of May, 1931.

Sulfur Bibliography Published Publication of "Bibliography of Organic Sulfur Compounds," the first work of its kind, has been announced by the American Petroleum Institute.

The 188-page volume, prepared by Dr. Parry Borgstrom, Naval Research Laboratory; Dr. R. W. Bost, University of North Carolina, and Dr. D. F. Brown, Standard Oil Development Company, contains approximately 4000 literature and patent references presented as a concise summary of the information on sulfur chemistry related to the petroleum industry for the years 1871 to 1929. The authors have made an examination of the "Journal of the Chemical Society (London)," for the period 1871 to 1907, and of "Chemical Abstracts," for the period 1907 to 1929, checking each literature reference with the abstract journal and each patent reference with the official file in the U. S. Patent Office. Every effort has been made to minimize the number of errors.

The scope of the literature study has been limited to sulfur compounds which may occur in petroleum, their properties, uses, and methods of removal from petroleum products. These are classified in 34 groups. Where more than one classification for a reference is required, the reference is listed in the first appropriate group, with cross reference entries at the end of the other groups. The scope of the patent section is the same. The patent references are placed in seven classes, the period covered ranging from 1852 to January 1, 1930.

The volume has been published without profit by the Institute as a service to petroleum technologists and others interested. Copies, at $4.00 each, may be obtained from the Institute, 250 Park Avenue, New York.

L. R. Roberts, who has been process superintendent for many years at the South Wales plant of Anglo-Persian Oil Company, has joined the London office staff of The Texas Oil Company, Ltd.

R. R. Dean has resigned his position as chief engineer of Independent Oil & Gas Company's gasoline department and is associated with John Haggart petroleum engineering consulting work with Tulsa offices.

B. D. Oliviera, formerly chief clerk at the El Paso refinery of The Texas Company, has been transferred recently to the West Tulsa plant, receiving a silver set from fellow employes at the time of his departure.

John A. Mann has resigned as chief chemist at the refinery of Phillips Petroleum Company, and has accepted a position as chief chemist at the refinery being erected at Tenerriffe, Canary Islands, by the Spanish government. He was formerly with the Bureau of Mines for two years.

John R. Huffman, who left Yale Graduate School in 1929 and has just completed a year of research work at the University of Copenhagen, has joined the staff of the Research Laboratories of Standard Oil Development Company, Elizabeth, New Jersey.

F. Laverne Miller, formerly research assistant at the University of Michigan, has joined the staff of the Research Laboratories, Standard Oil Development Company.

R. E. Wilson, assistant to the vice president in charge of manufacture, Standard Oil Company (Indiana), Chicago, has had added to his duties those of director of all research for the corporation.

Wallace A. Craig has resigned from Union Oil Company and is now associated with Asano Bussan Company, San Francisco, as petroleum technologist.

A. Donald Green has left the engineering department of Salvay Process Company and is now connected with the research department of Standard Oil Development Company, Elizabeth, New Jersey.

H. L. Smith, formerly assistant superintendent of Pure Oil Company's Muskogee, Oklahoma, refinery, has been transferred to the new refinery at Toledo, Ohio, leaving Muskogee November 28. G. T. Yost succeeded Mr. Smith at Muskogee, being transferred from the Marcus Hook, Pennsylvania, plant. Harry Blackwell was transferred from the Marcus Hook plant November 15 to Toledo, where he has assumed his new duties as master mechanic.

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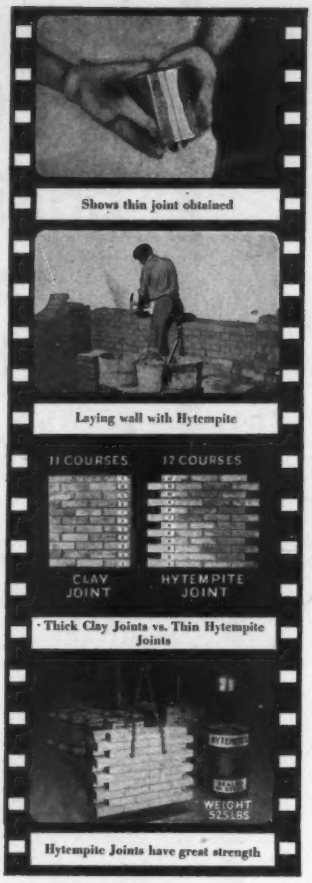

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Refinery and Gasoline Plant Activities

New Plants – Construction Notes – Personnel Changes

Announce Three Refineries, Five Gasoline Plants

NEW projects in the manufacturing branch of the industry reported during the past month are confined for the most part to additional cracking units, three small refineries, and five new natural gasoline plants. Nothing new has been announced during the month concerning foreign activities which has not been previously discussed in these columns.

In Arkansas the formation of Dayson Petroleum Company was announced and this company proposes a small refinery near Smackover. In Texas, Exchange Petroleum Corporation is reported erecting a small skimming plant at Albany. Crown Refining Company, a new California organization, proposes erecting and testing a new process on a site near Sante Fe Springs; and Hy-Test Petroleum Products Company, Terra Bella, California, has proposed erection of a small lube oil plant. McKean County Refining Company, Farmer's Valley, Pennsylvania, has awarded contract for the constructiton of a 2500-barrel tube still.

A new cracking unit, vapor phase type, with 500-barrel capacity has been announced for Vernon Refining Company, Vernon, California. A 750-barrel Dubbs unit is under construction for Ohio Valley Refining Company, St. Marys, West Virginia, and a similar unit of same capacity is being erected for Emlenton Refining Company, Emlenton, Pennsylvania. Associated Oil Company, California subsidiary of Tide-Water Associated Oil Company, is progressing in the construction of its 10,000-barrel capacity Tube & Tank cracking unit at Avon.

Expansion work of various classes is reported at a number of plants. Skelly Oil Company at its El Dorado, Kansas, refinery is building a new grease plant of 500,000 pounds monthly capacity, and a new barrel cleaning unit to handle 250 barrels daily. Muskegon Refiners, Inc., is reconditioning and enlarging its 500-barrel skimming plant following reorganization of the company. Canadian Oil Company, Ltd., has announced plans for enlargement of its refinery at Petrolia, Ontario, Canada. Regal Oil & Refining Company, Calgary, is also expanding through the addition of new treating facilities.

Joplin Refining Company, Joplin, Missouri, has acquired the plant of Wilhoit Refining Company and plans operating at capacity of 1500 barrels per day. Crown Central Petroleum Corporation, Houston, with a 10,000-barrel refinery on the Houston ship channel has been acquired by the Blaustein interests of Baltimore, Maryland, which also controls American Oil Company. Lone Star Gas Company has organized Lone Star Gasoline Company in contemplation of acquisition of the Chestnut & Smith Corporation and subsidiaries, Smith-Hanlon Inc., Brooks & Hanlon, Inc., and Naturaline Company of America.

Empire Gas & Fuel Company is nearing completion of two natural gasoline plants, one being near the Konawa field in Oklahoma and the other southeast of Pampa in the Texas Panhandle. Exchange Petroleum Corporation, Albany, Shackleford County, Texas, is building an 8000-gallon gasoline plant to handle gas from the townsite pool. Union Production Company, according to reports plans building a natural gasoline plant in the Pettus field, Texas. Beldridge Oil Company has completed its plant of 50,000 gallons capacity in the Beldridge, California field, and, Pacific Western Oil Company has completed enlarging its Ventura field plant.

Large Cracking Units

Associated Oil Company, California subsidiary of Tide Water Associated Oil Company, is progressing rapidly with construction of its 10,000-barrel cracking unit of Tube & Tank type at its Avon, California, refinery. The refinery has a rated capacity of 60,000 barrels. This marks the entry of Associated Oil Company into cracking on a major scale. Several years ago it experimented with a small vapor phase cracking system. This is also the first unit of Tube & Tank process to be erected on the West Coast. Further details were announced in the Month in Review department of the November issue of Refiner and Natural Gasoline Manufacturer, page 62.

Complete Gasoline Plant

Beldridge Oil Company has completed construction of its natural gasoline plant in the Beldridge, California, field with a rated capacity of 50,000 gallons daily, taking gas from the company's Well No. 15. Additional wells drilling to the Temblor zone in this area indicate the necessary installation of additional plants. Operating conditions resemble those of Kettleman Hills as the plant will be operated at a well pressure of 450 pounds. Gasoline content is reported at one gallon per 1000 feet. The plant was built by the J. A. Campbell Company.

Refinery Enlarging

Canadian Oil Company, Ltd., has announced plans for the enlargement of its refinery and storage facilities at Petrolia, Ontario, at an estimated cost of $250,000.

Blaustein Acquires Crown Central

Crown Central Petroleum Corporation, Houston, which operates a refinery on the Houston ship channel near Pasadena, has been acquired by the Louis and Jacob Blaustein interests of Baltimore, Maryland, through purchase of majority of stock. In addition to the refinery, properties include docks, bunkering facilities and pipe lines. Plant ca-

REFINERY AND GASOLINE PLANT ACTIVITIES

pacity is reported at 10,000 barrels per day. The acquiring interests also control American Oil Company. This company is reported as being partly owned by Pan-American Petroleum & Transport Company, subsidiary of Standard Oil Company (Indiana.)

Test New Process

Crown Refining Company, recently incorporated in California, plans construction of an experimental cracking plant to test a new process invented by Franz B. Howard, Los Angeles. The company is reported negotiating for a site near Santa Fe Springs. Rollin McNitt, attorney, Los Angeles, is handling the company's affairs. Details of the new process are not now available.

New Arkansas Refinery

Dayson Petroleum Company has been organized by Sylvester Dayson, formerly vice-president Lion Oil Refining Company, El Dorado, Arkansas, and F. C. Winters, formerly chairman of the board of the Lion organization. The new refinery of Dayson Petroleum Company will be located at Smackover, have a rated capacity of 300 barrels daily, will produce lubricating oil, road oil, and naphtha, and is to be ready for operation January 15.

New Cracking Units

Emlenton Refining Company, Emlenton, Pennsylvania, has begun construction of its Dubbs cracking unit, with Universal Oil Products Company in charge of installation. The cracking unit has a daily capacity rating of 750 barrels. Additional distillation and auxiliary equipment consisting of boiler plant and filter house included in the $1,000,000 expansion program is under construction.

Two Empire Plants

Empire Gas & Fuel Company is nearing completion of two natural gasoline plants in Oklahoma and Texas Panhandle. The Oklahoma plant is being erected near the Konawa field in Section 6-6, with an initial capacity of 5,000,000 cubic feet of gas daily. The Texas plant is located on the Empire-Sullivan lease, four miles southeast of Pampa, Gray County, Texas. Capacity 20,000 gallons daily. This gives the Empire companies a total of 20 gasoline plants in Kansas, Oklahoma and Texas.

New Skimming Plant

Exchange Petroleum Corporation has construction under way on its small skimming plant located near the townsite of Albany, Texas. The plant will have a rated capacity of 200 barrels per day.

West Texas Plant

Exchange Petroleum Corporation (Wichita Falls, Texas), has acquired a two acre tract in the SW of Section 19, Block 11, T. & P. Survey, Shackelford County, upon which it will erect an 8000-gallon natural gasoline plant to treat gas being produced on the Albany townsite pool. The same company is reported erecting a small refinery at Albany.

Lube Refinery Proposed

Hy-Test Petroleum Products Company proposed the construction of a lubricating oil refinery at Terra Bella, California, after a series of experiments on a commercial scale wherein the old equipment of the Seegar refinery at Maricopa was utilized. Hy-Test Petroleum Products Company operates the Nacogdoches Refinery, Inc., Nacogdoches, Texas, producing only lubricants, using a vacuum process (see Refiner & Natural Gasoline Manufacturer issue of July, 1930, page 73).

Wilhoit Refinery Sold

Joplin Refining Company has acquired the refinery at Joplin, Missouri, formerly operated by Wilhoit Refining Company. It consists of a 1500-barrel skimming plant and one 1200-barrel Jenkins cracking unit. C. S. Banks who was general manager and refinery superintendent for the Wilhoit company will continue in that capacity with the new owners. A. E. Basinger is president; W. F. Maher secretary and treasurer, and George Ogden is sales manager.

Lone Star Gasoline Company

Lone Star Gasoline Company has been organized by Lone Star Gas Company for the purpose of taking over Chestnut & Smith and other properties. A special meeting of Chestnut & Smith Corporation stockholders on December 16 will definitely approve or disprove this proposed deal. The properties involved are in Texas; Chestnut and Smith Corporation and its subsidiaries, Smith-Hanlon, Inc., Brooks & Hanlon, Inc. and Naturaline Company of America are included.

New Tube Still

McKean County Refining Company, Farmer's Valley, Pennsylvania, has awarded contract to E. B. Badgers & Sons Company for construction of a 2,500-barrel pipe still topping unit and small control house. Work is at present underway.

Mexican Refinery

Mexican Eagle Oil Company Ltd. (Royal Dutch Shell group) has received permit to construct a refinery near Mexico City, and proposed capacity is reported at 12,000 cubic meters daily. Previous reports concerning this plant and pipe line from tidewater were published in the Refiner and Natural Gasoline Manufacturer, issue of August, 1930, page 145 and issue of November, 1930, page 162.

Enlarge Michigan Refinery

Muskegon Refiners, Inc., is reconditioning and enlarging the 500-barrel skimming plant erected in the Muskegon field, Michigan, about 18 months ago, but never operated. The company has filed articles of association with Naph-Sol Refining Company of North Muskegon. Walter E. Anderson has purchased the inoperative plant of Muskegon Refiners, Inc., and is president of the present company. He was formerly president of Old Dutch Refining Company. A. W. Penny, Muskegon attorney, is secretary-treasurer of the company. Jack Helme is vice-president and superintendent of the plants operation. This plant was originally moved from Lexington, Kentucky, where it had been operated as the Lafayette Refining and Storage Company by A. V. Smith.

Cracking Unit Building

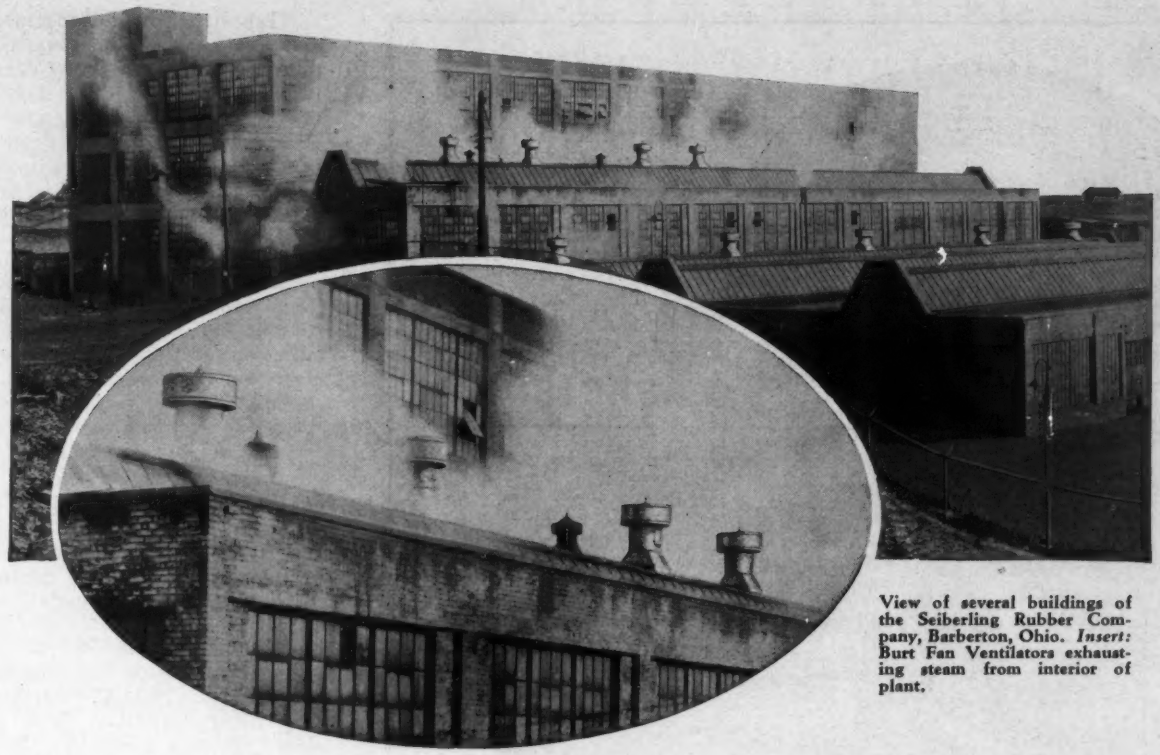
Ohio Valley Refining Company, St. Marys, West Virginia, is installing a 750-barrel daily capacity Dubbs cracking unit, with installation work in charge of Universal Oil Products Company.

Enlarge Ventura Plant

Pacific Western Oil Company has remodeled and enlarged its Ventura field natural gasoline plant through installation of additional compression equipment. This plant was acquired with certain other properties, from Petroleum Securities Company, about a year ago. Production of gasoline is now about 20,000 gallons per day.

Phillips Enters Wyoming

Phillips Petroleum Company is exploring with core drill on a block of 30,000 acres leased (and 75,000 acres under option) east of Douglas and west of the Lance Creek field, Wyoming, and reports from the state indicate possible erection of a refinery or gasoline plant and pipe line into Omaha. Reiter-Foster Corporation, the Shoup interests of Colorado, Midwest Refining Company and The Texas Production Company are reported interested in this territory.



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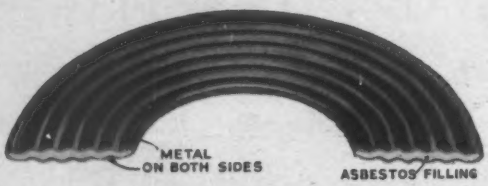

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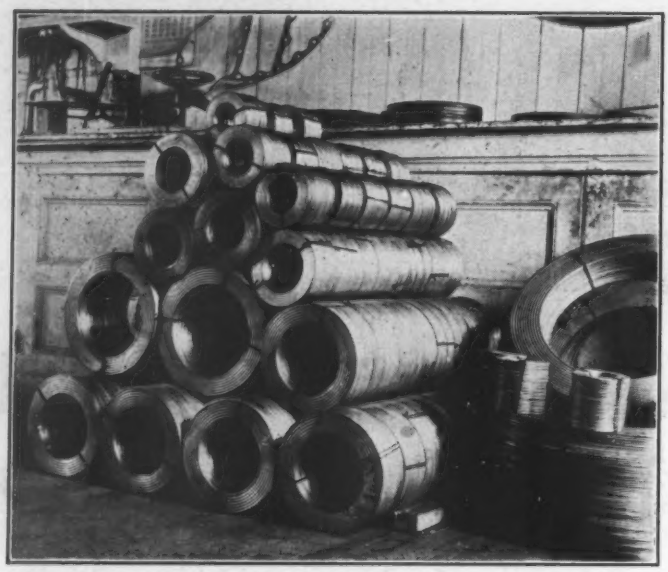

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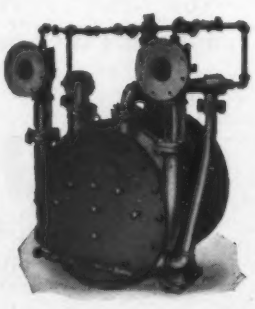

C. H. WHEELER of PHILADELPHIA

Gasoline Plant Proposed

Red Feather Oil Company and Producers Oil & Gas Company developing the Baggs structure near Baggs, Wyoming, plan the installation of a natural gasoline plant contingent upon the successful joint development of sufficient natural gas in this field, and will supply the town of Baggs with gas.

New Treating Plant

Regal Oil & Refining Company, operating its refinery in the Manchester subdivision of Calgary, Canada, using Turner Valley crude, is building the first unit of a new chemical treating plant at a reported cost of $50,000.

New Grease Plant

Skelly Oil Company at its El Dorado, Kansas refinery, is installing a new grease compounding plant with a capacity rating of 500,000 pounds per month. Kettles will be installed as follows; two 1,000-gallon capacity, two 250-gallon size, one 500-gallon pressure kettle and two 250-gallons measuring kettles. P. V. Bartholow is grease plant foreman. The building housing the new plant is a three-story structure totalling about 9,000 square feet of floor space. Raw materials will be stored on the top floor, compounding and finishing kettles in the second floor, and filling, packaging equipment on the first floor, with pumping equipment and products stored in the basement.

Pettus Gasoline Plant

Union Production Company, according to reports, plans building a natural gasoline plant in the Pettus field, Texas and is laying pipe line into the field to gather the gas, the north end of which produces wet gas suitable for gasoline extraction. This will be the second natural gasoline plant in the Gulf Coast territory, the first now under construction at Raccoon Bend, by Humble Oil & Refining Company.

Building Cracking Unit

Vernon Oil Refining Company has started construction of a 500-barrel cracking unit of vapor phase type at its Vernon, California refinery. The unit is expected to be in operation in early spring. This company has operated a skimming plant at Vernon for the past several years. Rated crude capacity is 3,000 barrels.

Proposed Gasoline Plant

Humble Oil & Refining Company, at its Raccoon Bend pressure maintenance plant, plans construction of an absorption natural gasoline plant to be placed in operation early in the Spring. The present compression plant is producing gasoline under compression methods. The new absorption system will improve efficiency of gasoline extraction and will be the first absorption type unit in the Gulf Coast producing district. Braun equipment will be used with rated capacity of about 10,000,000 cubic feet of gas daily.

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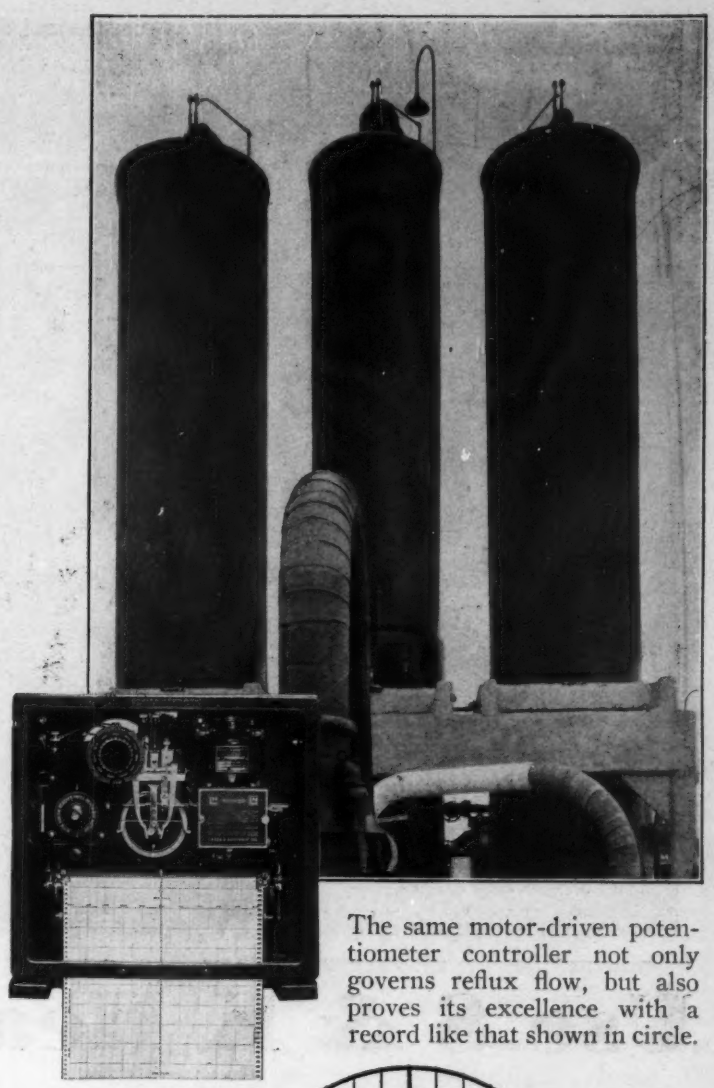

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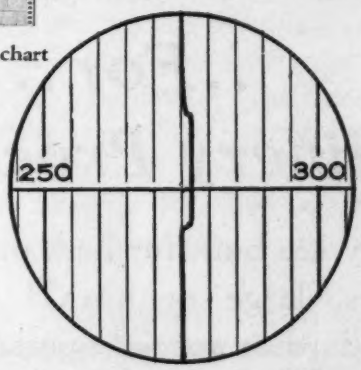

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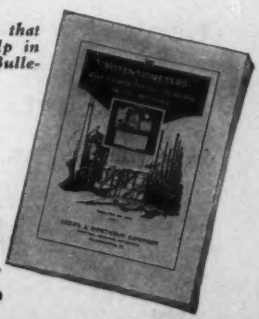

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L & N Potentiometer Pyrometers—Different From All Others—Most Accurate In Industry

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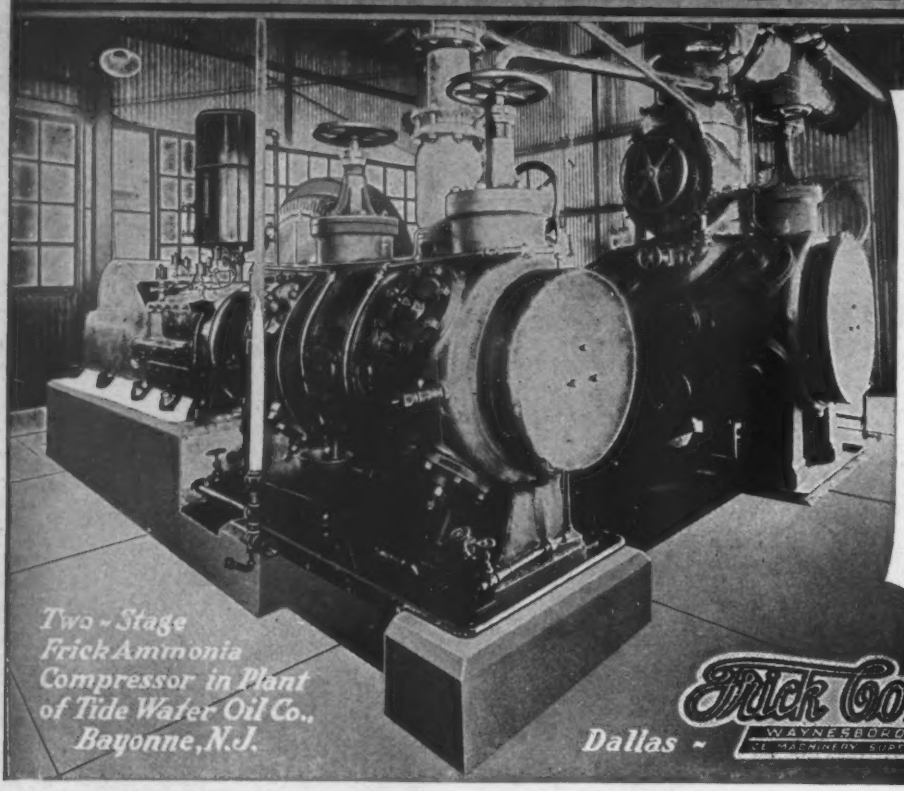


Two-Stage Frick Ammonia Compressor in Plant of Tide Water Oil Co., Bayonne, N.J.

—25°

TRADE FRICK MARK

—50°

For Low Temperatures

Having built and installed all types of cooling plants for industrial purposes, handling temperatures down to 50 and even 109 deg. below zero Fahr., we are in position to solve your special cooling problems with Frick Refrigeration. You are invited to use our 48 years experience in this work.

Write, wire or 'phone.

Frick Company
WAYNESBORO, PA., U. S. A.
"Ice Machinery Superior Since 1882"

Dallas - - Kansas City

Use S & K Heat Exchangers

..For.. Refinery Processes!

They are built for high or low pressures, large or small capacities, standard or special operating conditions.

Single unit, two-unit and multiple-unit designs.

Send for Bulletin 12-H

SCHUTTE KOERTING

1253 N. 12th Street

PHILADELPHIA, PA.

A Real Substantial, Durable Valve for Your Various Acid Conditions

Carolina ACID VALVES

Made of Lead Alloy, Special Cast Iron and of Various Alloys to Suit Acid Conditions

1. Renewable plugs and stems.
2. Renewable seats.
3. Rising stem with very short travel.
4. Extra long stuffing box that can be packed while in operation.
5. Studs for packing gland operate from top of yoke so that they will not come in contact with acid in case of leaks around stuffing box.
6. Stuffing box can be packed while in operation.
7. Amply large hand wheel.
8. No sticking.
9. Extremely heavy construction and very durable.
10. That part of valve stem that has been in the acid does not protrude above the stuffing box.
11. Absolutely acid resisting.
12. Constructed of various alloys to suit your acid conditions.
13. Drainage gland around the stuffing box in case of leak.

Made in either straight line or angle type.

Charlotte Chemical Laboratories

CHARLOTTE, N. C.—*New York Office:* 50 E. 42 St.

Southwestern Distributors:
GENERAL SUPPLY CO., Houston, Texas

Designed by Engineers with 25 Years Experience in Acid Plants

Saves money on jobs like this

IS your tank car washing costing you more than you think it ought to? If it is, investigate this simple Oakite method that so many other concerns are finding profitable to use in washing cars painted white, aluminum or any other color.

Simply apply the proper Oakite material the Oakite Service Man will recommend, using either spray equipment or the Oakite flow-on method. Grease, dirt and other foreign matter are thoroughly loosened, so that a light swabbing and rinse remove them completely. Surfaces dry clean and film-free. Paint is brighter, colors show up like new. And, when a regular Oakite cleaning schedule is adhered to, repainting is needed less frequently.

Complete information on this money-saving Oakite method is available through the near-by Oakite representative. A post card brings him to your plant.

Oakite Service Men, cleaning specialists, are located in the principal industrial centers of the U. S. and Canada

Manufactured only by
OAKITE PRODUCTS, INC., 50B Thames St., NEW YORK

OAKITE
TRADE MARK REG. U.S. PAT. OFF.
Industrial Cleaning Materials and Methods

MELLOWED A HUNDRED MILLION YEARS
MELLOWED A HUNDRED MILLION YEARS
MELLOWED A HUNDRED MILLION YEARS
MELLOWED A HUNDRED MILLION YEARS
White scaly monsters fought in PENNSYLVANIA
SINCLAIR
MOBILINE

POWER—a By-Product
in making
Sinclair Mobiline

In Sinclair's big, new refinery two 750-Kw. Moore high back pressure turbo generator units furnish process steam and generate all power as a by-product.

These units operate on steam at 400 lbs. 200 deg. superheat and **exhaust into a 125 lbs.** steam header which supplies various equipment and processes throughout the plant.

Power is generated at a minimum cost and the proper balance between process steam and electrical load is attained by use of highly efficient Moore multistage steam turbines designed for these particular conditions.

Every Moore turbine is especially designed to best suit the conditions under which it will operate.

STEAM TURBINES REDUCTION GEARS CENTRIFUGAL PUMPS

Moore Steam Turbine Corporation
Wellsville, N. Y.

Offices in all principal cities

New Equipment for the Modern Plant

Viscosimeter

C. J. TAGLIABUE MANUFACTURING COMPANY

C. J. Tagliabue Manufacturing Company, 18-88 Street, Brooklyn, announces the new Tag Saybolt thermostatic viscosimeter, which retains the leading features of the original Saybolt standard universal viscosimeter for testing the viscosity of lubricating oils, and adds a number of new features.

Tag Viscosimeter

The temperature of the bath is held constant within plus or minus 1/10 of a degree at any test point between room temperature and 220 degrees F. The new Tag thermostatic system is designed to allow easy setting to the correct temperature by means of a pilot lamp which indicates whether the contacts are open or closed by the appearance of the lamp. A flickering light seen from any point of the room shows that the bath is being controlled and is operating properly.

To prevent sticking contacts one contact is oscillated by means of a cam on the propeller shaft. The oil is used as a liquid instead of employing the use of water. The original Saybolt standard viscosimeter tubes either with or without universal Furol orifices are retained.

The manufacturers will furnish more complete details upon request.

Steel Spring Recording Gauge

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, has perfected during the current year an alloy-steel helical spring movement for its recording gauges, which represents an advance in pressure gauge design. The new movement is of one piece tubing, all steel and all welded. It is designed to combine maximum safety with high resistance to commonly encountered corrosive agents. It has no solder nor brass in the construction.

The steel spring gauges are built to allow uninterrupted service. During the past two years the company has placed steel welded movements on high pressure work in central stations, casing and tubing work in the natural gas fields, cracking units in refineries, various processes in air reduction plants and on processes. Tests have resulted in a finding of accuracy to within less than one per cent.

These alloy-steel movements are available with all new Foxboro recording gauges, or separately, to be installed in old Foxboro gauges. The new movements are used on gas, water, steam, oil, air, brine, chemicals, etc., where pressures do not exceed 2000 pounds per square inch.

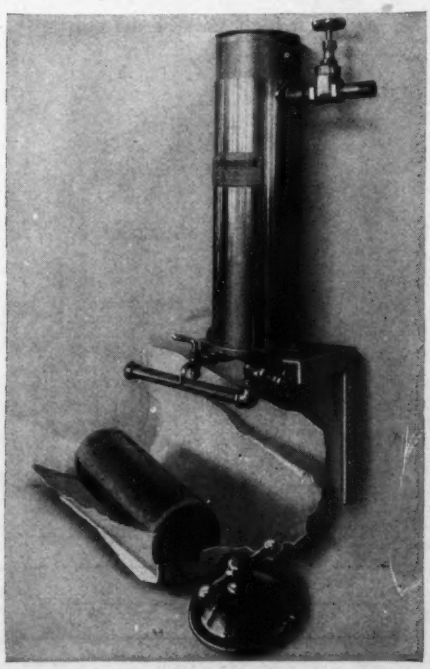
With the introduction of this new gauge movement the Foxboro Company has prepared Bulletin 168, which describes these gauge movements in detail. Copies may be had by writing to the Neponsett Avenue, Foxboro, Massachusetts, office.

New Filter

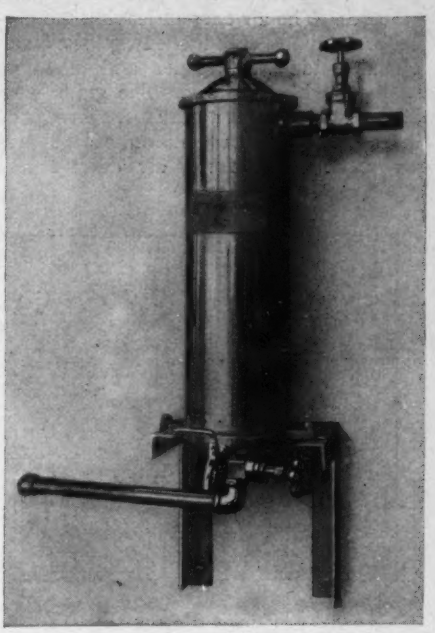
ALSOP ENGINEERING COMPANY

Alsop Engineering Company, 39 West 60th Street, New York City, is shortly placing on the market a new filter, the design of which is to provide for supplying a large quantity of filtered water without clogging up and to allow cleaning out in two minutes.

The filter, or a number of them, depending on capacity desired, connects to any pipe line, and the water passes



Alsop Filter



Alsop Filter

through with little drop in pressure. By shutting off the inlet and outlet valves, the lid can be removed for inspection, and if the filter medium is found to be very dirty, it only takes two minutes to remove a screen on which is wrapped two layers of heavy French filter paper, and re-wrap with clean filter paper.

All parts are of brass or bronze, and are finished in polished nickel. Chromium plates are supplied with the filter.

Model Number 1 has 400 square inches of filtering area. Pipe connections are three-quarters of an inch. The capacity is 15 gallons per minute at 25 pounds pressure. It is constructed to stand 100 pounds per square inch pressure. Two or more filters may be connected in parallel for greater capacity, in which case one filter may be cleaned while the other is still in operation.

Alsop Engineering Company will forward complete details upon request.

Vanco Blower

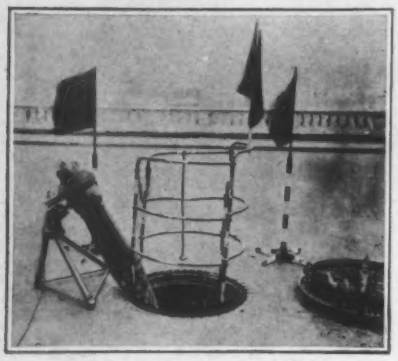
COPPUS ENGINEERING CORPORATION

Coppus Engineering Corporation, Worcester, Massachusetts, has developed the Coppus Vanco blower for expelling accumulations of carbon monoxide or other dangerous gases rapidly. Its use is chiefly for ridding manholes of gases which make work hazardous. Under tests on jobs this blower has expelled an accumulation of gas which under older methods required approximately one-half hour.

The equipment is a propeller type blower like that now used extensively in plants for process work, exhausting tanks and boilers, ventilating purposes and cooling and drying operations.

Stationary guide vanes beyond the pro-

peller represent one of the outstanding features. The air current leaving the propeller radially sub-divided by the individual guide vane blades and taken up by them without shock. The guide vane blades, which have a curvature increasing in the direction of rotation of the propeller, concentrate the air current and



Vanco Blower

give it a further acceleration inside of the stationary guide vanes so that a considerable part of the pressure is produced in the latter. A large part of the end thrust is thus taken up by the stationary guide vane casing. The air streams, into which the flow of air has been sub-divided by the guide vane blades leave the guide vane casing, on account of the kinetic energy, slightly rotating and convergent toward the axis so that the smallest section of the air flow is reached beyond the guide vane casing.

This blower is light weight and portable, weighing less than 100 pounds, and may be set and operated by one man. Attachment for the electric current is made at any convenient outlet.

Additional information is available by writing the manufacturers.

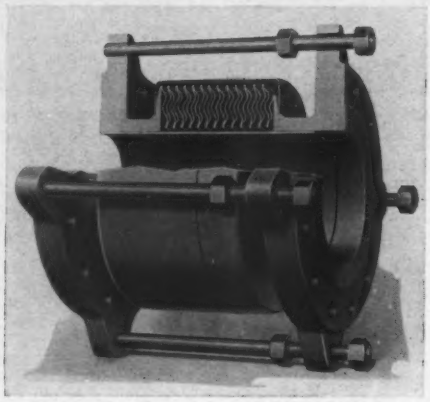
FlexoDisc Expansion Joint

CROLL-REYNOLDS ENGINEERING COMPANY

The Croll - Reynolds Engineering Company, 17 John Street, New York City, has placed on the market the FlexoDisc expansion joint, a new type of expansion joint for pipe lines.

This joint is designed to permit free movement of the piping without strain through the use of a flexible heat treated nickel steel expansion element, welded to cast steel flanged heads which are guided relative to each other to permit longitudinal movement only. A special design is offered where lateral or angular misalignment must be provided for.

The expansion element is a completely welded assembly of corrugated nickel steel discs. After welding, which



Flexo Disc Expansion Joint

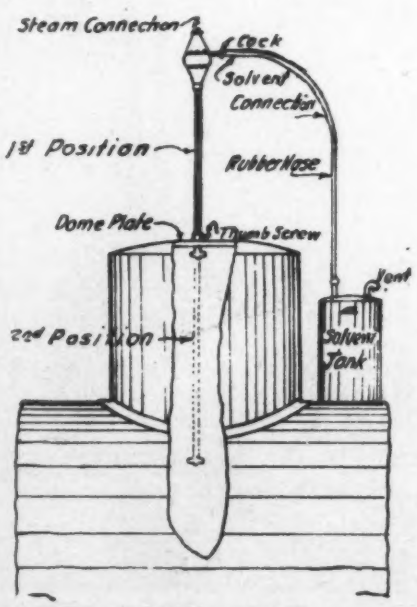
is done by the General Electric atomic hydrogen process, the complete element is heat treated to obtain uniform quality, maximum strength, and freedom from all local stresses due to welding.

In operation, the movement of the FlexoDisc expansion joint is analagous to the action of a coil spring, in that the element takes up the expansion and contraction of the piping by the elastic deflection of the plates.

This new expansion joint is now available in various types suitable for working pressures up to 30, 125, or 250 pounds, with either flanged or welding ends. Larger sizes and types for higher pressures will soon be offered.

Where corrosion is important, stainless steel construction is used. Thus this expansion joint is particularly suitable for oil refinery and pipe line work where severe working conditions are often encountered.

Complete information on the FlexoDisc expansion joint is given in bulletin No. 40 which will be sent upon request.



J. S. Vaporizer

New Vaporizer

J. S. ENGINEERING COMPANY

The J. S. Engineering Company, 1027 Annunciation Street, New Orleans, has recently placed on the market the new J. S. vaporizer for cleaning the inside of tank cars and metal tanks.

This product is scientifically designed to clean by the evaporization of inexpensive solvents by steam. The steam, being saturated with the solvent, vaporizes on being discharged through nozzles to dissolve such materials as crude and other oils or solidified matter. After being dissolved, the foreign matter is largely expelled along with the condensate of the steam through the unloading opening during the steaming operation. Any small residue is then flushed out with water.

This vaporizer may also be used to spray the proper chemicals used to extinguish tank or other interior fires.

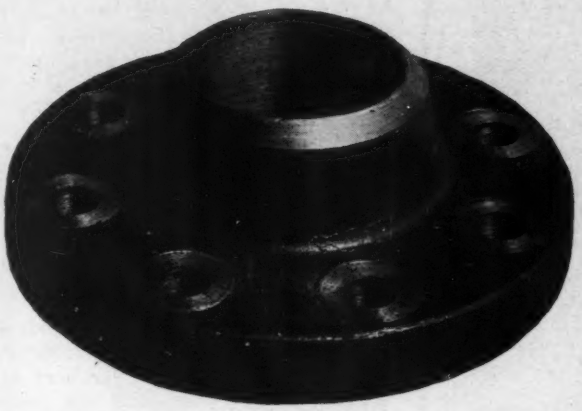
The vaporizer may be used with steam, air or gasses, whichever is proper for the purpose.

The accompanying illustration shows an outline of the vaporizer. The outlet in the bottom of the tank car is opened wide before installing the vaporizer. A temporary manhole cover is placed in the manhole and clamped. The vaporizer is inserted in the manhole cover and the collar clamped. The vaporizer is then drawn up full height through the collar and a set screw tightened. The steam line is then connected to the one-inch pipe at the top of the vaporizer and opened full to steam heat the dome for 10 minutes. The vaporizer is then lowered full length through the collar and the body of the car steamed for 20 minutes or more, according to the weather. Steam is then shut off and the vaporizer drawn up again to the dome. The small globe valve in the side of the vaporizer is opened about one-sixteenth-inch. A can of solvent is set on the car and connected to the vaporizer by a rubber hose. The needle valve is opened wide. The steam line is again opened wide and the flow of solvent is drawn into a mixture near the spray by a vacuum created by the steam flow. The solvent flow is regulated by closing the needle valve to the point where the can will empty in 30 to 45 minutes. In about 10 minutes the vaporizer is again lowered full length to clean the body of the car.

After cleaning, the solvent can is filled with water one or more times, opening the globe valve about one-quarter open and closing the needle valve, thus giving the car a hot water bath. The car is then cooled by disconnecting the steam line and attaching water pressure to the steam pipe in the vaporizer.

A high safety factor is attained

TAYLOR
Butt Welding Flanges
For Welded Pipe Lines



Taylor Flanges are gaining consistent favor throughout the oil industry because of the many economies they effect in the field. Can be quickly and easily attached by electric or acetylene welding—assure strong, tight, leak-proof connections. Available in sizes 1" to 96" diameter for all pressures.

Send for Bulletin 30-5

TAYLOR FORGE & PIPE WORKS, *Chicago*
Box 485, Chicago, Ill. 50 Church St., New York, N. Y.

Wishing You A Merry Christmas

ELIMINATE BOILER SCALE AND CORROSION

USE ALNAPOS

Alnapos is an improved form of Sodium Aluminate which removes impurities from feed water, places a protective film on metal surfaces, and counteracts dissolved oxygen, thus reducing scale formation and corrosion.

Alnapos eliminates "foaming," causes true water gauge readings, reduces explosion hazards, assures safety of men and cuts down fuel bills.

Alnapos is economical, the average daily cost being less than 14c on boilers up to 40 H.P.

Write, wire or phone for prices and material and your order will be filled immediately.

WARD CHEMICAL CORP.

510 East Grand,
Oklahoma City, Okla.
Phone 2-2504

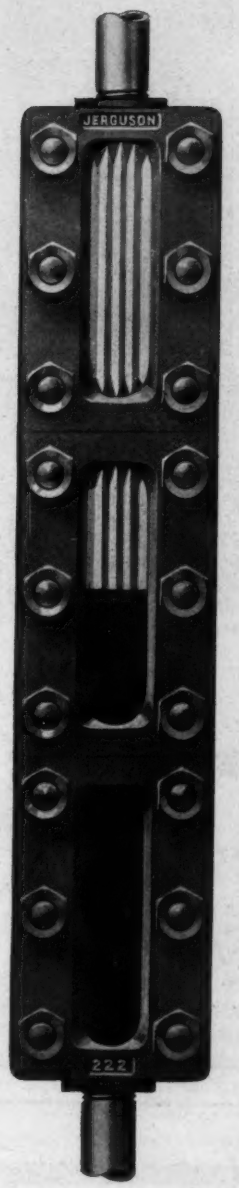
34 No. Guthrie,
Tulsa, Oklahoma
Dial 4-8135

IN TEXAS — DALLAS AND WICHITA FALLS

JERGUSON
REFLEX GAGES

have been used for steam boilers for 25 years and are now being used by leading oil companies for indicating oil levels in tanks, towers, stills, etc.

The *empty* space appears WHITE



The *liquid* shows BLACK

They are safe and durable at the highest pressures and temperatures. We can furnish gages with or without valves for every type of service. Full information upon request.

Jerguson Gage & Valve Co.

87 FELLSWAY
SOMERVILLE, MASS.

PX-33 *proves its merit in difficult installations*

Longer Life

Easy application

Low maintenance cost

Burner port for injection of powdered coal — made with PX-33. Illustrates one of many proper uses of a *moldable* furnace lining.

PX-33 is unfired fire brick in stiff, mud-like form — a highly-developed refractory with a melting point of 3250° F. (Cone 33). Developed for entire furnace linings, patching, and replacing special shapes; for arches, jams and other installations where pre-fired refractories are at a disadvantage.

Due largely to the use of calcined virgin flint fire clay plus scientific control of grain sizes, PX-33 has exceptional strength throughout all stages of temperature development. PX-33 is highly resistant to spalling, slagging and melting.

Write for Bulletin

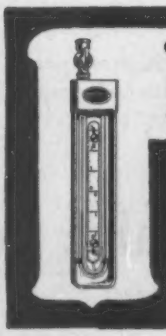
THE DENVER FIRE CLAY COMPANY

DENVER DFC COLO. U.S.A.

BRANCHES AT SALT LAKE CITY, EL PASO, AND NEW YORK

D F C *Distributors:*

El Paso, Texas—Neff Stiles Company
Houston, Texas—Ires Prosser
Los Angeles—H. F. Bakemeyer
New Orleans—J. J. Clarke Co., Inc.
Ogden, Utah—Ogden Press Brick & Tile Company.
Phoenix, Arizona—V. L. Clark Building Material Co.
Portland, Oregon—Kline Specialty Co.
Provo, Utah—Provo Brick & Tile Co.
Reno, Nevada—Flanigan Warehouse Co.
San Francisco—W. E. Mushet Co.
Santa Fe, New Mexico—Santa Fe Builders Supply Co.
Wichita Falls, Texas—Greene Brothers



Manometers

THE MERIAM CO.

1954 West 112th St., Cleveland, Ohio

through this method because of no exposed parts on the vaporizer. The solvent container is sealed and fitted with an Underwriters vent to prevent danger of combustion in the tank or container.

Complete details on this new product will be furnished by the manufacturers upon request to the address given above.

Boiler Treatment

SUGAR BEET PRODUCTS COMPANY

Sugar Beet Products Company, Saginaw, Michigan, has recently published a booklet dealing with boiler feed water problems and their elimination. In this booklet are outlined the services which deal with these problems.

This service includes a laboratory analysis of the boiler feed water being used and the proper sugar beet boiler treatment to eliminate scale, priming, foaming, pitting, corrosion and electrolysis is prescribed.

Sugar beet boiler treatment comes in dry concentrated powder form, is sold by the pound and is shipped in barrels, halves and quarters.

The company makes a broad guarantee as to specific results obtainable and savings to be made.

Further information can be secured direct from the company at Saginaw.

Foxboro Gauge

Pressure Gauge

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, has developed an indicating pressure gauge designed specifically for oil refineries. All parts subject to pressure are of steel and are sweated and screwed tightly into place to prevent the development of leaks due to high pressure or high temperature conditions.

A special alloy steel Bourdon spring is used to allow the gauge to be operated continuously at maximum scale reading without fatigue. The flange case is of cast iron and is made fume tight. It

THE HOIST THAT DOES NOT REQUIRE REPAIRS FOR YEARS.

FIFTEEN FEATURES

of UNION HOISTS are not obtainable all together on any other hoists. These include

Reversible Load Sprocket
(an exclusive feature)
insuring twice the durability of the usual hoist construction.
Large Roller Bearings
Solid Load Axle Alloy Steel
Cut Alloy Steel Gears
Electrically Welded Tested Chain
Forged Steel Hooks
All in Steel Suspension
Tested to 50% overload.

Complete, new and well-illustrated Hoist Catalogue will be sent on request. Also, on request, new catalogue of UNION CHUCKS.

Union Manufacturing Co.
New Britain, Connecticut

Branch Offices Carrying Stocks:
—NEW YORK, 26 Cortlandt St.; CINCINNATI, 332 Sycamore St.; CHICAGO, 27 S. Jefferson St.; SAN FRANCISCO, 661 Folsom St.; HOUSTON, I. Van Tassel, 1120 Union National Bank Bldg.

UNION HOISTS

An exhaustive treatment of piping principles and practice

Piping Handbook

By J. H. WALKER

Superintendent of Central Heating, The Detroit Edison Company,
and
SABIN CROCKER
The Detroit Edison Company

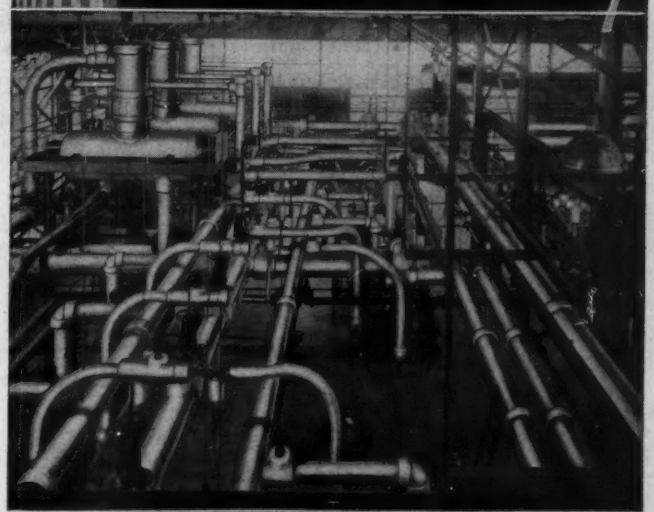
764 pages, 5 x 8, illustrated, $5.00

The purpose of this book is to provide authoritative, and accessible data for the engineer interested in piping work. Every needed fact is given, covering scientific fundamentals, materials, and most effective methods.

This book is intended to make available to the engineer, contractor and designer a complete handbook of the data necessary to the most effective use of piping in its many and increasingly important industrial applications.

GULF PUBLISHING COMPANY
P. O. Box 1307
HOUSTON TEXAS

PIPING by



Power Piping
FOR EVERY OIL FIELD NEED

Refineries are exacting

To meet the ever-increasing requirements of this rapidly growing industry and to keep pace with the latest scientific achievements, refineries require the most modern equipment and give strict attention to maintenance and upkeep. Their demands are exacting—but it is a tribute to this organization that "POWER PIPING" has met their needs efficiently and economically through the years!

POWER PIPING COMPANY
PITTSBURGH, PA.

FROM A MERE FITTING
TO A COMPLETE SYSTEM

An airplane view of part of a refining plant at Ponca City, Oklahoma, showing our cooling tower. This tower is 60 feet high.

Cooling Water From 150 Degrees to 74 Degrees

THE 70 degree wet bulb is the July average for Oklahoma. Our problem was to design a cooling tower which would cool water going on the tower at temperatures from 125 degrees to 150 degrees to a point within 5 degrees of the wet-bulb, cooling over a range as much as 75 degrees.

The solution to the problem was a cooling tower 60 feet high with twenty decks. That cooling tower was installed almost four years ago, and the results to date have been entirely satisfactory. Records have been kept of the daily and often hourly performance of this tower, and true wet-bulbs have been taken with a sling psychrometer as well as stationary wet-bulb readings, so that the performance of the tower has been checked in every way against the cooling results it was designed to accomplish.

Not every refining plant has a water cooling problem like this. We cite this merely to show that our engineering department can handle difficult assignments when necessary. Ordinarily our Standard Type Cooling Towers will meet your requirements perfectly. They are described in our Bulletin 283-R, a copy of which will be sent on request.

THE COOLING TOWER COMPANY, INC.

15 JOHN STREET, NEW YORK

Representatives in Principal Cities

TULSA
Whealton & Townsend, Inc.,
120 E. Brady St.

HOUSTON
J. A. Rossiter Company
410 Union Nat. Bank Bldg.

GAS BURNERS

Flame Burners
Short Flame Burners
Flameless Burners

Special Burner for Gasoline Plant and Refinery work.

Burns Rectifying column and Still gases with a short flame.

JOHN ZINK CO.

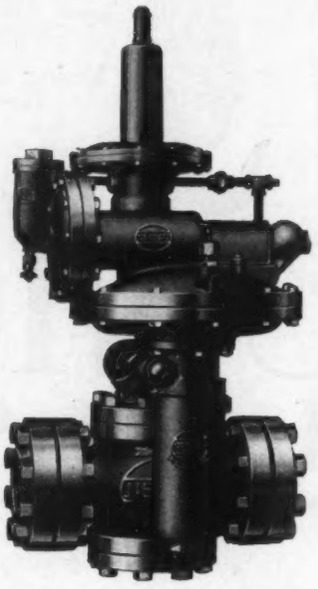
Oklahoma Natural Gas Bldg.
Phone 4-9838

TULSA, OKLAHOMA

has a cast iron threaded ring fitted with double thick glass litharged in place. The movement of the gauge is all steel. It has a cadmium plated movement plates, steel hair spring, extra wide bearing surfaces and hardened steel parts to withstand vibration and excessive pulsation. The dial and pointer are made of stainless iron.

This gauge is furnished only in a six-inch size with a bottom connection, forged steel socket, quarter-inch male S.P.T. pressure ranges available at the present time are: 0-300, 0-600 and 0-1000 pounds per square inch.

Additional information on the new refinery gauge may be secured by writing The Foxboro Company at Foxboro, Massachusetts.



Neilan Back Pressure Regulator

Back Pressure Regulator

NEILAN COMPANY, LTD.

Neilan Company, Ltd., 641-651 Santa Fe Avenue, Los Angeles, has introduced a unique new type of rotary-stem reducing or back pressure regulator for high temperatures and pressures. The modern high temperature cracking, refining and industrial processes utilizing both high and low pressures, are using this new type regulator.

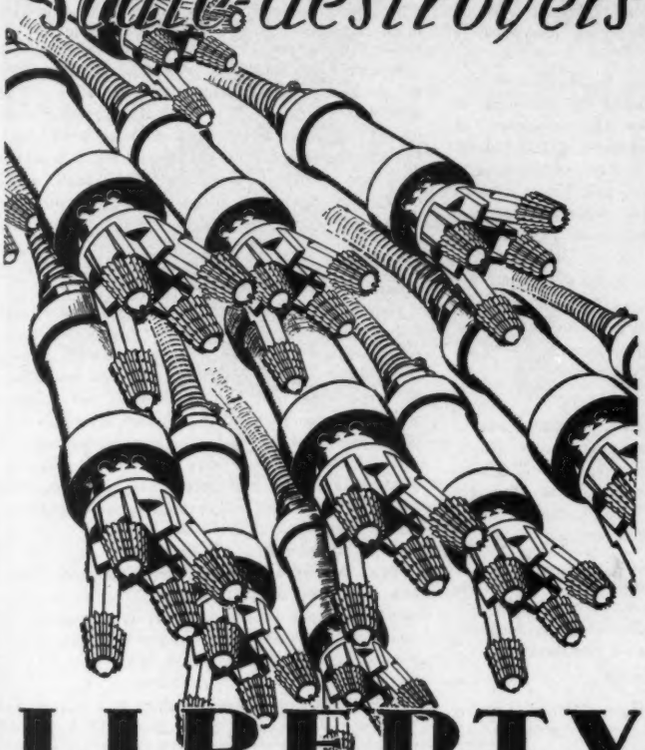
It is made with a rotary stem because this offers to allow it to be more tightly packed at high temperatures and pressures.

Special type of stuffing boxes are furnished for every different operating condition.

The valve bodies are made of high strength chrome-alloy cast steel, while the valve plugs, valve seat rings, complete rotary stem linkage and many other parts are made of non-corrosive, Nirosta KA2 stainless steel. To combat friction stainless steel ball bearings are used throughout the construction.

Descriptive literature is available from any Neilan engineer or by communicating with the company's headquarters office.

An army of scale-destroyers



LIBERTY Tube CLEANERS

A veritable army of Liberty cleaners is hard at it in oil refineries everywhere cleaning out carbon and scale deposits in all sorts of tubes and pipes. Everywhere, Liberty cleaners used periodically, cut, smash and drive out obstructing deposits, bringing back efficiency and cutting operating costs to the minimum.

Scale conditions vary, but no matter how tough the deposit, a Liberty cleaner designed for the duty will make a quick, clean job of it.

There are Liberty cleaners exactly suited to tubes and pipes, large or small, straight or curved. Write for the catalog and details.

LIBERTY MANUFACTURING CO.
JEANNETTE PENNA.

WYANDOTTE

76% Caustic Soda

for Service

QUARRIES, refineries, manufacturing plants, warehouses, rail and shipping facilities—all these factors essential to production and delivery are under Michigan's ownership.

Thus Wyandotte 76% Caustic Soda, from raw materials to final delivery, is under one control. In emergencies delivery can be made immediately, even in large quantities.

The daily routine of delivery on contract is uniformly prompt. Authorized jobbers everywhere are friendly and helpful.

Also Soda Ash, Bicarbonate of Soda and Calcium Chloride.

WYANDOTTE

"Distinguished for its high test and uniform quality."

MICHIGAN ALKALI CO.
General Sales Department
10 East 40th Street, New York City
Chicago Office: 435 North Michigan Boulevard
Works: Wyandotte, Michigan

ITEMS ABOUT MANUFACTURERS

American Rolling Mill Company, Middletown, Ohio, has published a new ARMCO engineering bulletin dealing with the suggested A.S.T.M. specifications for open hearth plates. It is a four-page illustrated bulletin for insertion in a loose-leaf folder. It will be sent upon request to the office shown above.

Bailey Meter Company, Cleveland, has issued a new bulletin entitled "Mechanically Operated Fluid Meters," and is distributing copies to interested persons. This bulletin, which is designated as No. 37, describes and illustrates various types of mechanically operated meters and auxiliary equipment for their installation. Colored meter chart records showing results obtained by the application of Bailey meters to various processes are included, together with sections on orifice and flow nozzle location, calibration, pulsating flow, special conditions and special applications.

This 52-page bulletin also includes a long list of users of mechanically operated fluid meters showing installation data for various services and fluids.

Babcock & Wilcox Company has issued a new bulletin on fusion welding. This publication discusses a new method of welding which, the company states, eliminates the necessity for long training or great skill on the part of the operator and produces welds equal to or better than the work metal in tensile strength, shock resistance, ductility, and the ability to withstand repeated stresses. These characteristics are illustrated by photographs and descriptions of test specimens, chemical analysis, micrographs and photomicrographic studies.

A chapter of this bulletin is devoted to the non-destructive tests employed by Babcock & Wilcox Company to prove the efficiency of welded seams in finished products without damage to the product in any way. Photographs of X-Ray studies are shown, and a new electro magnetic tester is described which hunts out defects in welds and records their presence on a graph.

The bulletin also shows how these non-destructive tests have been checked and verified.

Copies of this publication may be had by addressing Babcock & Wilcox Company, 85 Liberty Street, New York City.

Bigelow-Liptak Corporation, Detroit, manufacturers of suspended furnace walls and arches, announces the appointment of Charles C. Plummer as manager of sales office in Chicago. Plummer was formerly Chicago district manager for R. H. Beaumont Company of Philadelphia.

Bigelow-Liptak Corporation also announces the transfer of W. D. Dreiske to the Detroit office as sales engineer. Dreiske was formerly in the Chicago office of this company.

The Bristol Company has published Catalog No. 4000, describing the new line of Bristol air operated control equipment. It covers 20 pages and is cut for fitting in a loose-leaf book. This line of control equipment is outlined in detail and fully illustrated. A price list of the products is inserted. The catalog is available by writing the company's main office at Waterbury, Connecticut.

The Bristol Company, Waterbury, Connecticut, has issued a 20-page bulletin cut for insertion in loose-leaf folders, and presents an outline, illustrative of the company's control apparatus for temperature, automatic control valves, motor operated type and Bristol recording instruments. This booklet is supplemented with a price list, also cut to be inserted in loose-leaf form.

Coppus Engineering Corporation, Worcester, Massachusetts, announces the appointment of G. H. Bolle as district representative for the company in the New York territory. He will be located at 120 Liberty Street, New York City. He has served this company for a number of years in an engineering capacity.

De Laval Steam Turbine Company, Trenton, New Jersey, has issued a 40-page bulletin titled "De Laval Pumps, Turbines, Compressors and Speed Reducers for the Oil Industry." The publication contains chapters on the characteristics of centrifugal pumps when handling oil and other viscous liquids, on different hydraulic systems of balancing centrifugal pumps, on the effects of skin friction of impellers, and on the influence of the number of stages upon efficiency. A series of charts make it possible to determine the pressure loss due to the flow of oils of various viscosities in two-inch, three-inch, 4-inch, six-inch, eight-inch, 10-inch and 12-inch pipe lines; also the relation between viscosity and temperature. Various constants, formulas and tables of use to engineers and others concerned with oil refinery and pipe line problems are included.

This company has also published a leaflet, "A Pioneer in High Pressure Steam," which, with the above mentioned bulletin, is available upon request to the home office. This leaflet reveals that steam at near the critical pressure and with high superheat was used commercially in steam turbines as long ago as 1897. The Stockholm Exhibition of 1897 was supplied with power and light from four combined boiler, turbine and generator sets designed for a working pressure of 2850 pounds per square inch, while the log of operation shows actual pressures as high as 3420 pounds per square inch, and temperatures up to 750°F.

Much of the early work of Dr. De Laval is described in this pamphlet.

Other novel and original features of the Stockholm Exhibition were a flash type boiler, automatic control of combustion, independent control of primary air beneath the grate and secondary air above the fuel bed, cooling of the furnace walls and air preheating. Many drawings and photographs of the early designs are reproduced, together with illustrations of more modern apparatus of similar characteristics, including high pressure turbines and pumps, speed reducing gears, etc.

The Duriron Company, Inc., Dayton, Ohio, has appointed B. D. Spofford, formerly advertising manager for Waco Aircraft Company, advertising and publicity manager, effective November 1.

Fusion Welding Corporation, 103 Street and Torrence Avenue, Chicago, has published a 12-page illustrated catalog on welding accessories. It serves to supply the need for a handy guide for those requisitioning or ordering electric arc welding accessories and supplies. A complete line of these items is illustrated and described. A price list on items shown is carried. Copies may be had by writing the company's address given above.

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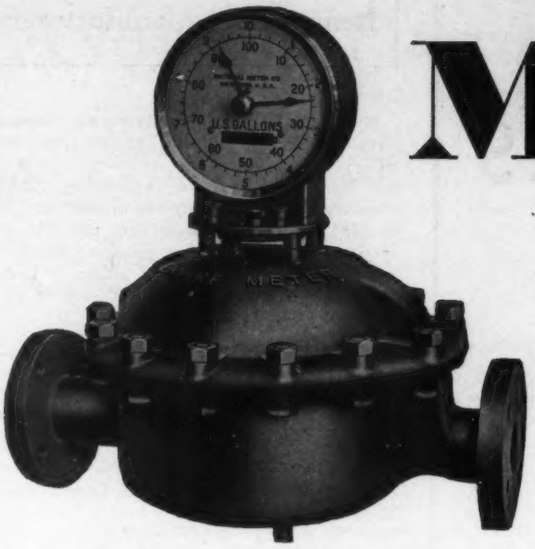

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For Accurate Measurement of Oil at any Stage of Refining, Shipping, Storage or Selling.

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Highly accurate. Strong and durable. Easy to install. Economical to maintain. Simple to operate. Requires no complicated servicing. Made in all sizes, from 5/8" to 6", in standard (150 lbs. working pressure to square inch) and high pressure (300 lbs. and up) types.

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The EMPIRE is different from every other type of meter offered for oil measuring work. The action of its measuring unit is a gentle, almost floating motion, with balanced pressures and a minimum of friction. This unique design enables the EMPIRE to hold its original high accuracy under operating conditions that quickly destroy the value of other types.

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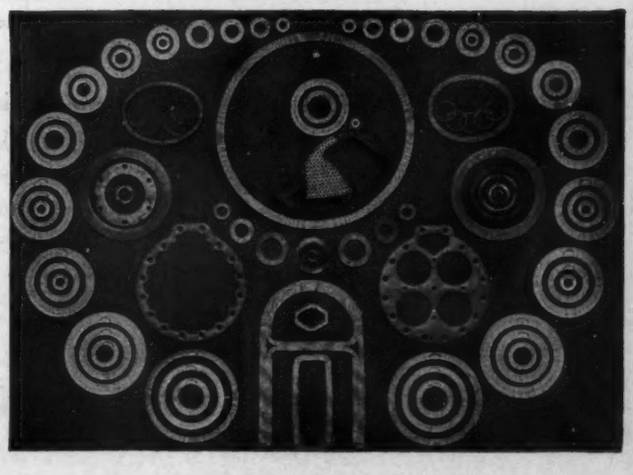

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Close-hook-up Type Flow Indicator

DIRECT READING
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ACCURATE

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FOR ANY SERVICE

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Manufacturing Engineers

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A Hearty Christmas Greeting

AND A GREAT BIG

THANK YOU!

for the many expressions of good will and good business that have come our way during the year past.

We hope to deserve your consideration in the future, as in the past, and greatly extend to you our sincere wishes for

A Happy, Prosperous New Year

PULMOSAN SAFETY EQUIPMENT CORP.

BROOKLYN, N. Y.

Items About Manufacturers

Hamilton Rubber Manufacturing Company, Trenton, New Jersey, has published two bulletins covering Hamilton contractors hose and the Hamilton fire hose, respectively. Illustrations show cut-away sections of hose to give a detailed outline of construction, and also show sections of the completed product. Price lists are included, and a copy of either or both of the bulletins will be sent upon request to the factory.

Harbison and Walker Refractories Company, Pittsburgh, has secured the services of A. M. Cullum, for the past 10 years connected with Reading Iron Company.

Harbison-Walker Refractories Company, Pittsburgh, has completed a 5000-foot motion picture illustrating modern methods employed in the manufacture of refractories. The film shows each step in the production of refractories from the mining of raw materials to the loading and shipping of the finished product. Scenes in the research and control laboratories and some interesting animated photography showing the action of periodic and continuous tunnel kilns, are also included in the picture.

This film, perhaps the most complete story of refractories ever made for the screen, is available without cost to technical societies, engineering organizations, industrial organizations, universities, colleges, technical schools and research laboratories. It is suggested that early applications be made to Harbison-Walker Refractories Company, 1800 Farmers Bank Building, Pittsburgh.

Heat Transfer Products, Inc., 30 Church Street, New York, has published Bulletin No. 1006, a 16-page loose-leaf publication which will be added to throughout the coming year to keep users of the bulletin up to date on the equipment of this company. The company's line of heat exchange equipment is completely covered in description and pictured with photographs and mechanical drawings, while the bulletin is replete with performance charts. A list of organizations served by Heat Transfer Products, Inc., is shown. A copy will be supplied upon request to the address shown above.

Kaye & McDonald, Inc., manufacturers of K-Master steam traps, 94 Franklin Avenue, West Orange, New Jersey, has published a pocket size folder on K-Master, the modernized inverted bucket steam trap, which presents to the reader the leading features of this trap in brief, outlined description, and pictures the trap assembled. This literature is available by writing the company at the above address.

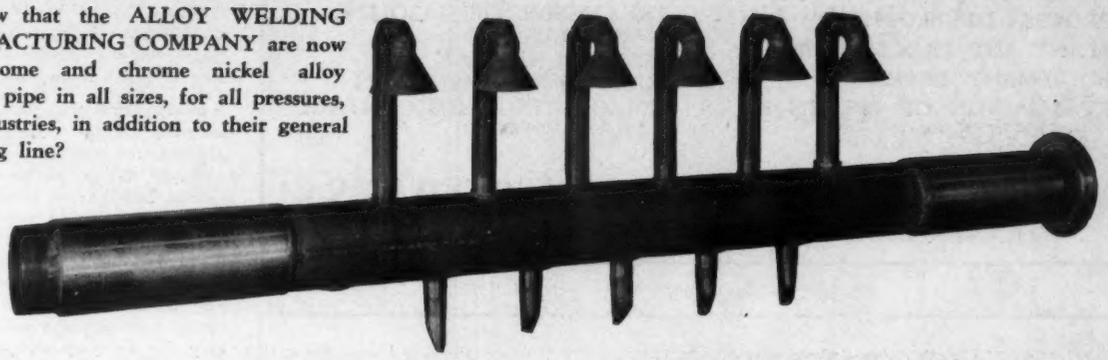
Arthur G. McKee & Company, engineers and contractors, 2422 Euclid Avenue, Cleveland, has published an illustrated folder showing several recent and typical operations of the company in the oil, iron and steel industries. A schedule of the company's work is pictured in chart form, to show the dispatch with which work of magnitude is executed while numerous other additions and extensions to plants are being made. The folder will be forwarded upon request to the company.

The Meriam Company, 1955 West 112th Street, Cleveland, has published a 48-page booklet entitled, "The Manometer and Its Uses." It deals exclusively with the man-

Alloy Pipe Fabrication for Every Purpose

Corrosion Resisting—Heat Resisting—Stainless

Do you know that the ALLOY WELDING AND MANUFACTURING COMPANY are now fabricating chrome and chrome nickel alloy (STAINLESS) pipe in all sizes, for all pressures, and for all industries, in addition to their general alloy fabricating line?



With a background of twenty-five years of experience in high pressure piping along with our wide experience in the fabrication of alloy steels, we are thoroughly equipped to produce units of all descriptions. Let us quote you on your requirements.

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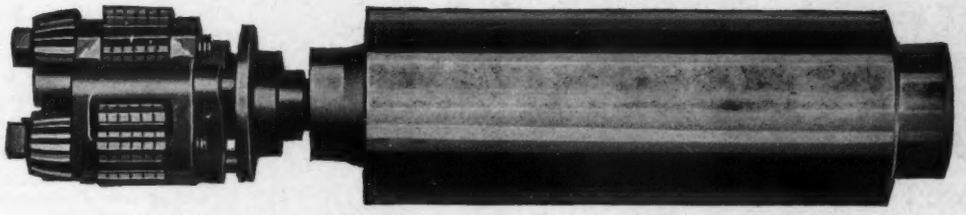
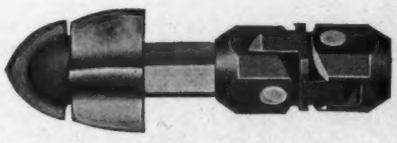


Roto air-driven Cleaner for Oil Still Tubes, made in sizes for 3″ tubes and larger.



Roto Still Type Drill Head

Roto Unit Drill Head

THE ROTO CO. — Sussex Avenue and Newark St., — NEWARK, N. J.

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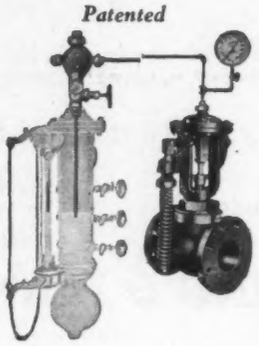
THE LESLIE LABORATORIES
TRAVER ROAD, ANN ARBOR, MICH.

A GUARANTEED
Boiler Feed Water Regulator

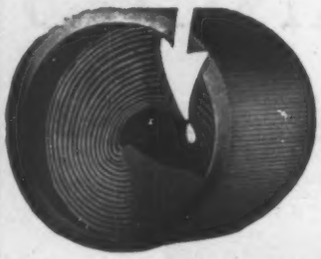
Patented



The CAMPBELL Boiler Feed Water Regulator is positively guaranteed to fulfill every claim made by us. It is priced at a figure within reach of the smallest refinery as well as the largest. Get full information on what the CAMPBELL is contributing to boiler economy in refineries all over the world. No moving parts. No thermostats. No floats. No generators. Simple. Rugged. Dependable. Easily installed. No servicing required.

ATLAS VALVE CO., 275 South Street, Newark, N. J.

The Spiral Motion Is the Trick



That's why Hood's Chemico Spiral Packing Rings have been selected by so many engineers. The center hole prevents choking and clogging.

Made of acid-resisting shale—practically indestructible.

Used by all big producers because of the intensive movements.

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FLOORS, STAIRS *and* LADDERS

KERLOW STEEL FLOORING COMPANY
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Items About Manufacturers

ometer, its operating principles and the uses to which it may be put. It is intended to fill the need for a handy and compact booklet dealing exclusively and comprehensively with the manometer, its operating principles and the uses to which it may be put.

Dealing first with the reasons for the basic accuracy of this type of instrument, J. B. Meriam, the author, describes the U-type and well-type designs principally used, as well as several little-known variations of the standard design for meeting unusual conditions. The methods of measurement of flow, pressure, velocity, etc., of steam, air, gas, ammonia, acids and other fluids are also dealt with in a simple way which, although omitting technicalities as far as possible, supplies the information necessary for carrying out practically every ordinary test which the engineer will be likely to encounter. A set of tables and useful data complete the handbook.

Neilan Company, Ltd., is distributing a new and comprehensive instruction book. This treatise is the result of several years of successfully building, installing and adjusting all types of Neilan equipment. It describes in detail how to hook up and adjust all Neilan control devices.

This Neilan book may be had by communicating with Neilan Company, Ltd., 641-651 Santa Fe Avenue, Los Angeles.

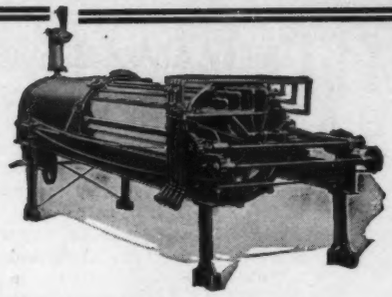
Peabody Engineering Corporation's directors, at a meeting held in November, declared a special dividend of $15 a share, payable to holders of common stock; and in addition, established a fund not to exceed $7 a share of the common stock to be distributed at once among the employes of the company in lieu of the bonus and profit-sharing usually made payable during the Christmas holidays. This action was taken as a contribution to the efforts being made in various quarters to hasten the return of normal business conditions.

Pittsburgh Equitable Meter Company has issued two new catalogs giving complete information about EMCO balanced valve regulators and new Emcorector. Anyone in the gas industry desiring a copy of either or both of them should direct his request to the company at 400 North Lexington Avenue, Pittsburgh.

Reading Iron Company announces the resignation of A. M. Cullum, effective December 1, as oil country sales manager, with headquarters at Tulsa.

Southwark Foundry & Machine Company, designers and builders of hydraulic machinery, power tools and special equipment, Philadelphia, has recently published a pictorial catalog, entitled "An Album of Engineering Achievement." More than 250 photographs used in this 64-page catalog tell the story of this company's products and their making. Most of the illustrations are from working photographs, showing interior operations of the company. A copy is available upon request to the company's headquarters office or to the branches, Swetland building, Cleveland, or Fisher building, Chicago.

B. F. Sturtevant Company, Hyde Park, Boston, and Sturtevant, Wisconsin, has published an oil refinery bulletin, No. 375, covering the company's refinery equipment, including high-



KELLYS *are Creeping up on* SWEETLANDS

SCORES of Oliver United's Sweetland Pressure Filters are now in service handling the various contact clays.

Already, more than a score of Kelly Filters are now in service cleaning up pressure still residuum.

That's a good record. Also a suggestion to other refineries bothered with a messy residuum.

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Every detail of American refinery practice — the most up-to-date developments as well as the standard methods — are fully covered in this book. Vapor phase craking, the production of high compression gasoline, the development of modern pipe stills, the use of Diesel engines in oil pumping, and hundreds of other subjects of equal interest and importance, are discussed, covering in full every detail of oil refinery operation, engineering, and design.

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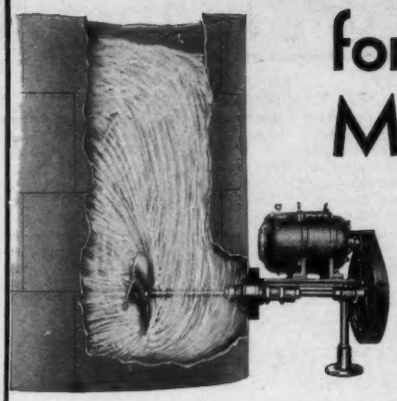

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For mixing any liquid in any large tank LIGHTNIN Side Angular Agitators will operate better, faster and much more economically than any other unit available for this purpose. Built for strength and lightness, their simplicity in design requires no new tank expense and an absolute minimum of operating cost. Their double action mixing efficiency has been acclaimed by production managers in 57 lines of industry where liquids are mixed. Write for details.

Fully Patented as to method and structure.

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LIGHTNIN Portable Mixers are built in all sizes and speeds, direct or geared types. Easily moved from tank to tank, making every container in your plant a complete mixing unit, they bring to smaller open or closed tanks the same famous double-action mixing efficiency as the LIGHTNIN Side Angular Agitator. Write for details.

ALL SIZES AND SPEEDS

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CHAPLIN-FULTON GAS REGULATORS have proved their claims for efficiency by their service records in all types of control conditions. Engineering skill has labored more than 40 years to bring these regulators to the peak of reliability. C-F performance the world over shows this skill has been rewarded. The Gypsy Oil Co. employs C-F Regulators at their Earlsboro, Okla., plant. Why not put these regulators to work on your job today, and in this accepted way obtain the most effective regulation available to you.

Our catalog will give you complete information concerning this equipment

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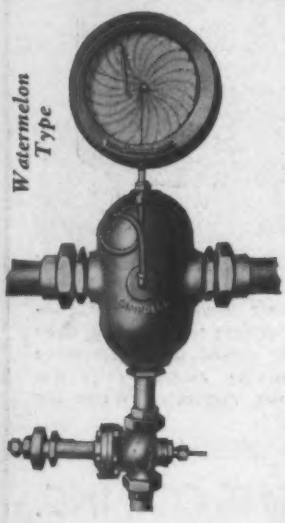

Watermelon and Pumpkinseed

We are frequently asked why we apply such names as "Watermelon" and "Pumpkinseed" to

CAMPBELL
Steam Flow Controllers for Oil Stills

By comparing the two photographs at the left you can "see" why. The body of the top photo is shaped like a watermelon and the lower one like a pumpkinseed. But, after all, the name of a device is not of great importance. The IMPORTANT points are: these Controllers actually CONTROL steam flow. They RECORD. They INDICATE. They do these things automatically and with precision.
Whatever your steam control problems may be place them in the hands of our engineers for solution. Scientific steam flow control for oil refineries is our specialty.

THE CAMPBELL ENGINEERING CO.
282 South St., Newark, N. J.
Manufacturers of the TAR BABY BURNER, to handle Fuel Oils, Water Gas Tar, Acid Sludge and Residue Fuels.
Without obligating us in any way, please send information on
☐ the Watermelon Type of Steam Control for Oil Stills;
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Name .....
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Items About Manufacturers

temperature recirculating fans, air preheaters, high-pressure propeller fans, oil economizers, mechanical draft fans and turbines, engines and motors. This 12-page bulletin, which is profusely illustrated, will be forwarded upon request to either of the above addresses.

C. R. Wheeler Manufacturing Company announces that Thomas B. Whitted, assistant to the vice-president, will be in charge of the company's New York office, Woolworth building, 233 Broadway, after January 1, 1931. Announcement is made also that Morris B. Carroll has jointed the organization and will be connected with the New York office. The new location in the Woolworth building has just recently been occupied by the company.

Louisiana Gas & Fuel Company will shortly put into operation at the Sugar Creek high pressure gasoline plant, near Arcadia, Louisiana, a plant with a capacity sufficient to handle 30,000,000 cubic feet of gas and designed to produce 30,000 gallons of gasoline daily. J. A. Campbell Company of Long Beach, California, equipment is used throughout; Stearns-Rogers Manufacturing Company, Denver, Mid-Continent representative of the J. A. Campbell Company, was given the contract for construction. This is the third Campbell equipped plant erected by Louisiana Gas & Fuel Company within the past year.

General Electric Company, Schenectady, New York, has issued a four-page loose-leaf bulletin on the low-speed synchronous motors, types TS and QS for direct connection to reciprocating compressors. Standard ratings on this "6000" series, large sizes, with welded steel-plate frames, range from 20 horsepower to 700 horsepower, 1.0 P-f, 60 cycles at speeds between 72 and 450 r.p.m. A copy of this illustrated bulletin for inclosing in a loose-leaf folder will be forwarded upon request.

General Electric Company has also recently issued a 40-page booklet on arc welding. This booklet is profusely illustrated, showing numerous electric welding jobs, including pipe line, tank, blower casings, manifolds, truck tanks, furnaces and other jobs.

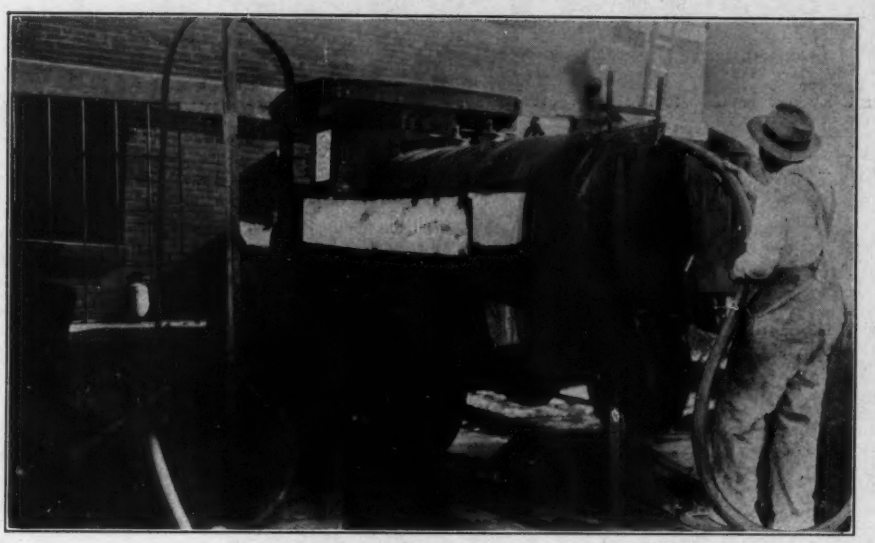
Another interesting piece of literature of General Electric of recent date is a pocket-size pamphlet devoted to covering G-E welding electrodes. Eight different types of G-E welding electrodes are shown and described followed by a section on G-E electric welding accessories and electric welding equipment. The company will forward a copy of this pamphlet upon request to the Schenectady headquarters, or to a district office of the industrial division of the company.

The Foxboro Company, Foxboro, Massachusetts, announces the publication of Bulletin No. 168 which is devoted to covering in description and illustrations recording gauges and steel springs. The booklet stresses the fact that the company's new gauges have all-steel, all-welded movements. The booklet is 24 pages and is cut for insertion in a loose-leaf folder. A complete lay-out on recording gauge specifications is carried in tabular form. This bulletin will be gladly forwarded by the Foxboro Company upon application to its home office, given above.

The Foxboro Company has also recently issued a 38-page bulletin on Foxboro V-Port Controlled valves. The various characteristics peculiar to Foxboro design in valve manufacture are explained in this bulletin in illustrated form. An interesting feature of the valve bulletin is the publication of a number of performance charts on these valves. This bulletin also is available by writing the company.

CHARLITE HEAVY DUTY No. 1
for Stripping Paint

Trucks, Tanks, Drums, Tank Cars, Quickly Cleaned For Re-painting



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An Unbeatable Combination
for Cutting and Threading 2½ to 4 inch Pipe!

Knives Feed Automatically

Fully Self-Contained No Loose Parts

No. 104 Beaver Square-End Cutter

A "one-piece" tool—with no loose parts! Self-centering "V" jaws center tool accurately . . . powerful springs force the knives through the pipe wall—quickly and automatically . . . almost impossible to break knives . . . nickel semi-steel castings—practically unbreakable . . . nothing to get out of order . . . so simple ANYONE can operate—either by hand or power . . . no other tool compares with the new Beaver No. 104 in simplicity—ruggedness—dependability. This "fool-proof" tool will pay for itself on one job!

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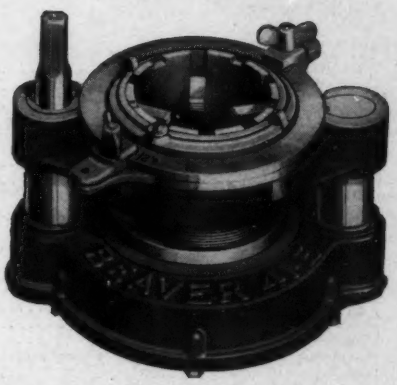
UNIVERSAL MOTOR

Cuts and Threads from ¼" to 12" inclusive

To satisfy the demand for Beaver Drives that can be used on either A. C. or D. C. current—and which will "reverse"—the No. 46 Beaver Power Drive is now announced.

It is simple, fool-proof, strong and will stand a tremendous amount of abuse. Beaver Power Drives never give trouble! Ask any user!



No. 41 Beaver Die Stock Semi-Self-Contained—Adjustable Improved Model

The new No. 41-E Beaver is an outstanding improvement. Gears are fully encased and packed in graphite grease. Impossible for dirt, sand, mud or chips to get in and wedge between the gear and pinion teeth and cause expensive repairs. No other tool offers this great advantage.

The use of our own special grade of nickel-semi-steel in the gear case—instead of cast iron, as in the past is another improvement which means greater strength and reduced repair bills.

The lower end of the pinion rides in a bronze-bushing—rigidly supported by the over-all cover plate of the gear housing. This plate is also of nickel semi-steel which provides greater rigidity—better threads and longer life.

Buy Them Through Your Jobber

THE BORDEN COMPANY, 518 Dana Ave, Warren, Ohio, U. S. A.

ADVERTISERS INDEX

The Air Preheater Corporation....170
The Louis Allis Company.... 56
Alloy Welding & Manufacturing Company....173
Alsop Engineering Company.... 60
American Meter Company.... 7
American Radiator Company....
The American Rolling Mill Company.... 8
Armstrong Machine Works.... 9
Arrowhead Iron Works....170
Atlas Valve Company....174
The Automotive Distillate Corporation....109

Babcock & Wilcox Tube Company....153
E. B. Badger & Sons Company....124-125
Bailey Meter Company....
The Bartlett Hayward Company....105
W. N. Best Corporation.... 62
Biggs Boiler Works....Third Cover
The Borden Company....177
Botfield Refractories Company.... 16
C. F. Braun & Company....Second Cover
Blaw-Knox Company....13 and 92
The Bristol Company.... 17
The Brown Instrument Company.... 12
The Burt Manufacturing Company....157
Byron Jackson Company.... 6

Calorizing Company....
The Campbell Engineering Company....176
J. A. Campbell Company....139
The Carbondale Machine Company....149
The Chaplin-Fulton Manufacturing Company....176
Chapman Valve Manufacturing Company.... 91
Charlotte Chemical Laboratories....161 and 177
Chicago Bridge & Iron Works.... 19
Clark Brothers Company.... 34
Consolidated Ashcroft Hancock Company.... 20
The Cooling Tower Company....168
Coen Company, Inc....137
Coppus Engineering Corporation....145
The Cooper-Bessemer Corporation.... 66

DeLaval Steam Turbine Company....154
The Denver Fire Clay Company....166
M. H. Detrick Company.... 22
J. P. Devine Manufacturing Company....110-111
Joseph Dixon Crucible Company.... 58
Diamond Alkali Company.... 21
Dresser & Gorton, Inc....143
The Duriron Company.... 62

Elliott Company.... 25

The Fisher Governor Company.... 24
The Fluor Corporation....
Foster Wheeler Corporation.... 31
Frick Company....160

General Insulating Company....
The General Manufacturing Company....170
General Refractories Company.... 29
Goetze Gasket & Packing Company....171
The Gray Processes Corporation....131
Greene, Tweed & Company.... 30
The Griscom-Russell Company.... 26
Gulf Publishing Company....120-121

The Haden Lime Company.... 53
Hammond Iron Works.... 11
Hanlon-Waters, Inc.... 32
Harbison-Walker Refractories Company....129
Hardinge Company.... 33
Heat Transfer Products, Inc.... 35
A. L. Henderer's Sons.... 60
Hills-McCanna Company.... 15
Homestead Valve Manufacturing Company.... 59
Hooker Electrochemical Company.... 28
B. Mifflin Hood Company....174
Hybinickel Alloys Company.... 4

Byron Jackson Company.... 6
Jackson Engineering Corporation....151
Jerguson Gage & Valve Company....165
Johns-Manville Corporation.... 37

The M. W. Kellogg Company....127
Kerlow Steel Flooring Company....174
Krupp Nirosta Company, Inc....

Lagonda Manufacturing Company....
E. J. Lavino & Company.... 61
Laclede-Christy 10

C. H. Leach Company....
Leeds & Northrup Company....159
The Leslie Laboratories....174
Liberty Manufacturing Company....169
Lincoln Electric Company.... 54
Walter E. Lummus Company.... 36

Maintenance Engineering Corporation.... 5
The Marley Company....
The Mathieson Alkali Works.... 14
A. Y. McDonald Manufacturing Company....Fourth Cover
The Meriam Company....166
Merco Nordstrom Valve Company.... 23
Metallo Gasket Company....158
Metric Metal Works.... 7
Michigan Alkali Company....169
The Midvale Company.... 63
Midwest Piping & Supply Company.... 99
Mine Safety Appliances Company....
Mixing Equipment Company....175
Moore Steam Turbine Corporation....162
Morey & Jones, Ltd....172
Multi-Metal Wire Cloth Corporation.... 49

National Airoil Burner Company.... 51
National Meter Company....171
National Transit Pump & Machine Company.... 38
National Tube Company.... 48
Neilan Company, Ltd.... 3
Newark Wire Cloth Company....119
North American Car Corporation....135

Oakite Products, Incorporated....161
The Ohio Steel Foundry Company.... 18
The Oil Conservation Engineering Company.... 64
Oil States Manufacturing Company....143
Oliver United Filters, Inc....175
The Oster Manufacturing Company.... 40

Page Fence Association.... 39
Peabody Engineering Corporation.... 50
Petroleum Engineering, Inc....
The Petroleum Iron Works Company....113
Pittsburgh Pipe Coil & Bending Company.... 55
Pittsburgh Steel Products Company.... 42
The Wm. Powell Company.... 44
Power Piping Company....167
Pulmosan Safety Equipment Corporation....172

Quigley Company....154

Reading Iron Company....101
Reading Steel Casting Company....123
Republic Steel Corporation.... 57
Ross Heater and Manufacturing Company....147
The Roto Company....173

Schutte & Koerting Company....160
A. O. Smith Corporation....94-95
Solvay Sales Corporation.... 46
Sowers Manufacturing Company....
Stockham Pipe & Fittings Company.... 27
Sun Ship Building & Dry Dock Company....141

C. J. Tagliabue Manufacturing Company....
Taylor Forge & Pipe Works....165
Techner-Myers Company....
The Terry Steam Turbine Company....115
Tulsa Boiler & Machinery Company....Front Cover
Turbo-Mixer Corporation.... 41

Union Carbide & Carbon Corporation.... 45
Union Carbide Sales Company.... 47
Union Manufacturing Company....167
Universal Oil Products Company....106-107

Henry Vogt Machine Corporation.... 43

Wagner Electric Corporation....133
Walworth Company....102-103
Ward Chemical Company....165
Waterous Company....
Westinghouse Electric & Manufacturing Company.... 97
C. H. Wheeler Manufacturing Company....158
Williams, Brown & Earle, Inc....170
The Winkler & Koch Engineering Company....116-117
Wyatt Metal & Boiler Works.... 52

York Ice Machinery Corporation....

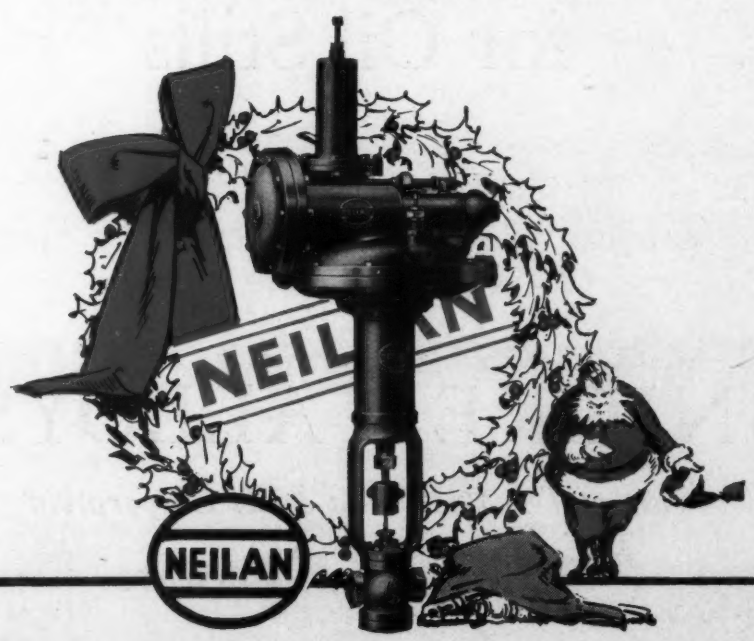
John Zink Company....168

A CHRISTMAS MESSAGE

AT THIS Joyous Holiday Season we gladly pause in the solving of regulating and control problems . . . to extend to our many friends and their families throughout the world . . . our most cordial wishes for a Merry Christmas and a Prosperous New Year.

NEILAN CO., Ltd.

AND ALL REPRESENTATIVES



HYBNICKEL

HEAT and ACID RESISTING CASTINGS

Several hundred tons of Hybnickel are now in use in oil refinery stills and superheaters.

One of Our Main Products Is—

Heat-resisting supports for Oil Stills

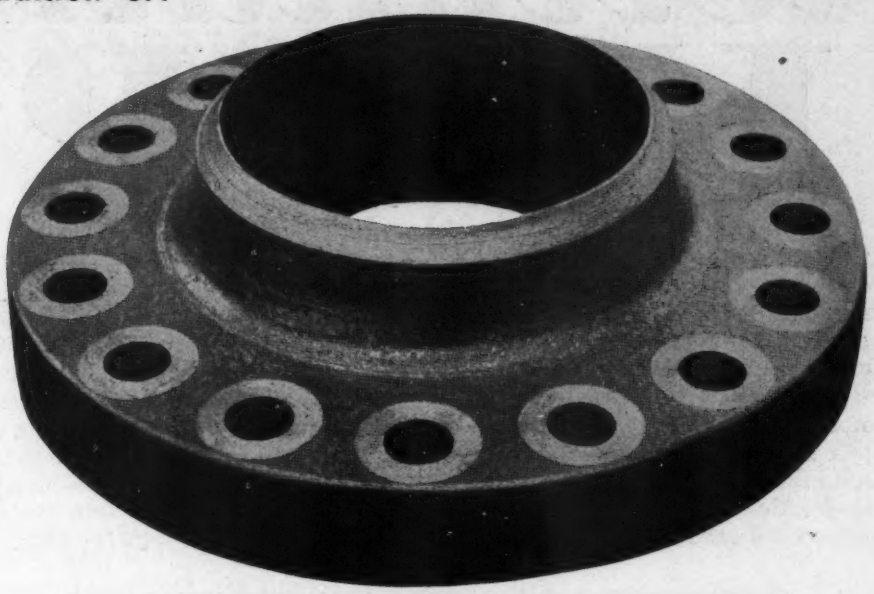
HYBNICKEL ALLOYS CO.

care of The Pusey and Jones Corporation

Wilmington, Delaware

Improvements are always welcome!

We announce the addition of:



FORGED STEEL BUTT WELDING FLANGES

In pipe sizes 2″ to 12″ inclusive

Both Standard (Series 15) and Extra Heavy (Series 30)

— To —

Our usual Houston and Fort Worth Warehouse Stocks of

FORGED STEEL FLANGES

Pipe sizes 1½″ to 18″ inclusive

Threaded or Bored for Welding as specified.

FLANGES manufactured by PHILADELPHIA STEEL & IRON CO., PHILADELPHIA, PA.

Maintenance Engineering Corporation

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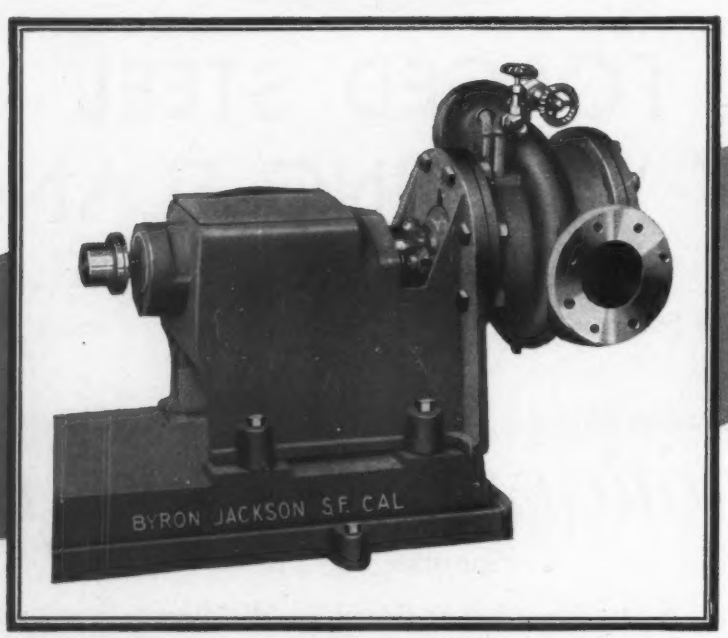
Offices and Warehouse — 500 East 9th Street; Phone — 2-2148

SPECIALTIES FOR PRESSURE AND TEMPERATURE

fractionating PUMPS

THE first sixteen of these pumps built have been in continuous twenty-four hour operation for three years without shutdown or repair. Impellers are designed to give a flat discharge characteristic, enabling the pump to deliver greatly increased volumes of fluid, if the head is decreased slightly. Centrifugal pumps, unlike positive displacement pumps, are subject to volumetric control, permitting the operator to maintain practically constant levels in the series fractionating towers. The pump has but one water-cooled stuffing box and provision is made for water quenching the gland to prevent flashing. The pump case has only one circular joint, kept tight by means of numerous stud bolts, and a metallic gasket. The rotating element may be removed from the case by taking off the outboard cover without disturbing pipe connections or the driver. These single stage pumps are constructed in a complete range of sizes for heads up to 150 feet. For higher discharge pressures, pumps having two or more stages are employed. Also centrifugal pumps for every refinery service.



SINCE 1872

BYRON JACKSON CO.

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Branches: NEW YORK and CHICAGO

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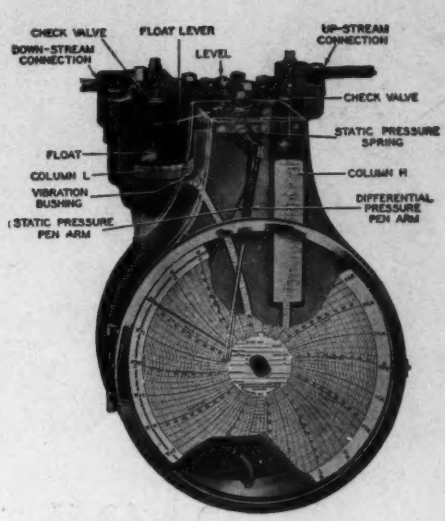
BYRON JACKSON

CENTRIFUGAL PUMPS FOR EVERY SERVICE

Now 15 years of dependable Westcott Service



Sectional View of the 100-Inch Westcott Orifice Meter
The 50-Inch meter is similar in design

SINCE 1915, when it was first installed on a natural gas line, the Westcott Orifice Meter has won dominant recognition in the natural gas, manufactured gas, natural gasoline and petroleum industries. Today it is extensively used as the standard measuring instrument, not only for gases, but for steam and many liquids.

You will find Westcott Orifice Meters clustered around industrial centers, also in many remote locations, where implicit trust *has* to be placed in reliable operation.

And through fifteen years of dependable service the Westcott has proved itself worthy of a world-wide trust. Its correct and up-to-date design, the exact construction of orifices and differential elements, the uniform excellence of recording mechanisms—all together have endowed this meter with a degree of accuracy above and beyond the most exacting requirements of orifice metering today.

FEATURES

Uniform area of the mercury chambers.

Large area of float.

Long length of lever arm.

Small angle of movement of the pen arm.

Minimum number of moving parts.

Leverage produced by mercury acting on a large-area float at the end of a long float lever insures sensitiveness and positive pen movement.

Floats and chambers especially treated so that the meniscus of the mercury is always of the same form.

Clearance between float and side walls always sufficient to permit mercury to surround the float entirely and prevent inaccuracy due to capillary attraction or dirt collecting on the mercury.

Even the slight shift of the center of gravity of the pen arm and connections, as the pen moves throughout the range of the chart, is counterbalanced.

Every Westcott Differential Gage is tested for accuracy against a water column at 10 different ranges and its accuracy is equal to the smallest visible reading on the test gage or chart.

AMERICAN METER CO
MEASUREMENT ENGINEERS
CUBIC FEET

METRIC METAL WORKS
ERIE, PENNSYLVANIA
Ironcase, Tinned Steel Case and Orifice Meters

AMERICAN METER COMPANY
Incorporated
The World's Largest Manufacturers of Gas Meters and Allied Apparatus
Established 1836

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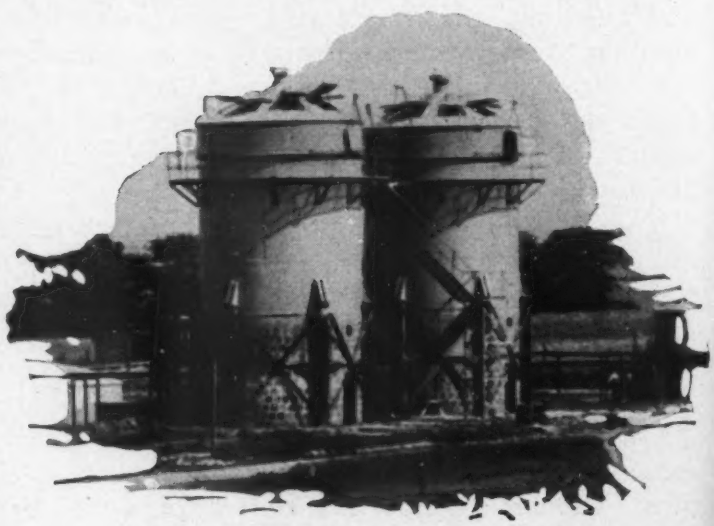
ARMCO INGOT IRON

helps thrifty refiners curb their corrosion losses

NOW, as for many years past, rust-resisting Armco INGOT IRON is waging war relentlessly against the corrosives that plunder the vital profits of refiners. In pipe, storage tanks, agitators, weak acid towers, heat exchangers, condenser boxes —in all equipment where a lasting, inexpensive metal is required, this durable iron is performing long, and *profitably*.

The records of the years attest to Armco INGOT IRON'S exceptional economy. During more than two decades this uniform pure iron has endured and conserved for its owners, in every field of service where plate and sheet equipment is used. It is significant to economy-seeking refiners that this period represents the longest record of actual service of any low cost, rust-resisting plates and sheets.

Armco INGOT IRON is readily available in plates and sheets of all standard sizes, thicknesses and gages, as well as in light-weight, smooth-bore spiral welded pipe. We shall be glad to consult with you concerning your problems and requirements.



These Armco INGOT IRON agitators, in the service of a large refinery at Wood River, Illinois, testify to the long, trouble-free performance of pure iron. They were installed in 1918, and at time of last inspection were in good serviceable condition.

Just write to the office nearest you.

TUNE IN—The Famous Armco Concert Band broadcasts every Thursday night, WLW—700 K. Cincinnati. Nine to nine thirty E.S.T.

Back of this familiar symbol is nearly thirty years' experience in the manufacture of special analysis iron and steel sheets and plates. When you want a rust-resisting, low-cost, metal, be sure to see this triangle and the words, "Armco INGOT IRON." It is your assurance of dependable, economical service.

THE AMERICAN ROLLING MILL CO.

Executive Offices: Middletown, Ohio

Export: The ARMCO International Corporation

District Offices: Chicago, Cincinnati, Cleveland, Detroit, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco, Tulsa, Houston

"BE SURE IT'S MADE OF ARMCO INGOT IRON"

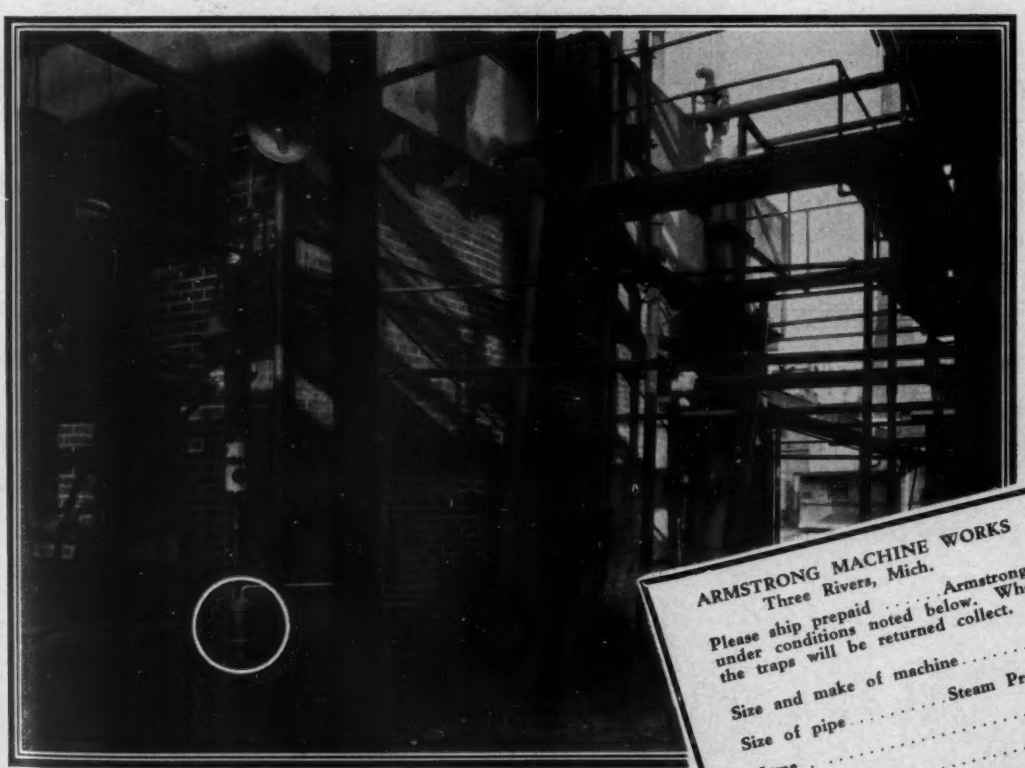
What Armstrong "non-airbinding" means in oil industry trapping

ONE of the outstanding features of Armstrong inverted bucket traps that has helped place more of them in service than any other mechanically operated trap is the impossibility of airbinding. Unlike most traps, the inlet is at the bottom, the outlet at the top. Air and undissolved gases rise to the top of the trap and are discharged with the condensate, yet the trap is always water sealed against steam leakage.

Since the Armstrong cannot airbind, heat exchange in stills, agitators, etc., is not handicapped by trapped air or slugs of water. Temperatures are controlled as positively as steam pressures. By such economical and efficient service the cost of the traps is returned many times in savings.

Besides their standard use on steam at pressures to 1350 lbs. and any degree superheat, Armstrongs are furnished for gasoline and other services at any pressure and temperature. Traps were recently supplied for gasoline service at 1500 lbs. pressure.

Let us furnish you with as many Armstrong traps as desired for 90 days free trial, without obligation. Prove that they cannot airbind, are self-scrubbing, have large capacity with small size, do not wiredraw. The coupon is for your convenience.



Armstrong Special Traps draining steam separators on line to stills.

ARMSTRONG · "INVERTED BUCKET" STEAM TRAP

ARMSTRONG MACHINE WORKS
Three Rivers, Mich.

Please ship prepaid ..... Armstrong Traps for a 90-day test under conditions noted below. When the test is completed the traps will be returned collect.

Size and make of machine .....

Size of pipe ..... Steam Pressure (Maximum) .....

Name .....

Position .....

Firm .....

Street Address .....

City and State .....

( ) Send Catalog.

R12-Gray

Armstrong Machine Works
Three Rivers, Michigan
District Representatives in 42 Cities

Laclede-Christy Air-Cooled Walls For Boilers and Oil Stills

Photos taken at plant of Phillips Petroleum Corporation, at Oklahoma City, Oklahoma

Upper: All steel and iron erected complete, ready for fire-tile.

Right: Complete wall.

Note These Construction Features:

1— Sturdy structural steel-columns with horizontal members.

2— Heavy castings, bolted to steel, spaced to provide for tile expansion.

3— Every casting forms a unit—removable at will.

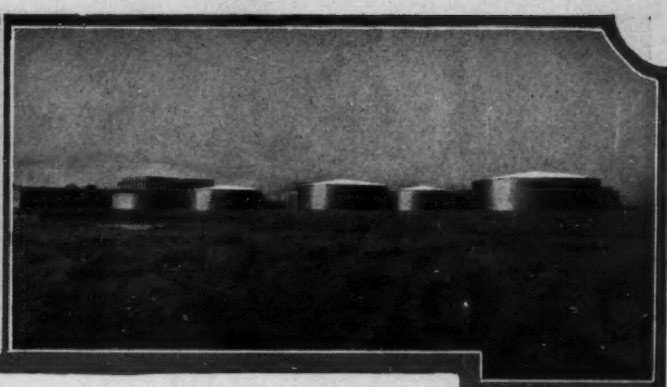
4— Air passes between wall and outer covering.—No leaks through wall.

5— Laclede-Christy Special Tile—but it costs no more than ordinary tile.

Write for Full Information and Prices

LACLEDE-CHRISTY • ST. LOUIS, MO.

N5R2



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Rice Leaders of the World Association
Represents High Standing in NAME-PRODUCT-POLICY

The "Copyrighted Slogan" tells the story. In every country where Petroleum Products are stored in steel tanks Hammond Tanks are used.

Steel tanks in capacities up to 100,000 barrels; knocked down or erected.

Oil Refinery Equipment, Stills, Towers, Agitators, etc.

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Our Bulletin No. 200—Storage Tanks.
Special Bulletin—Handling and Storing of Fuel Oil.

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New York Office: 17 BATTERY PLACE
Telephone: Whitehall 0060

Cable Address
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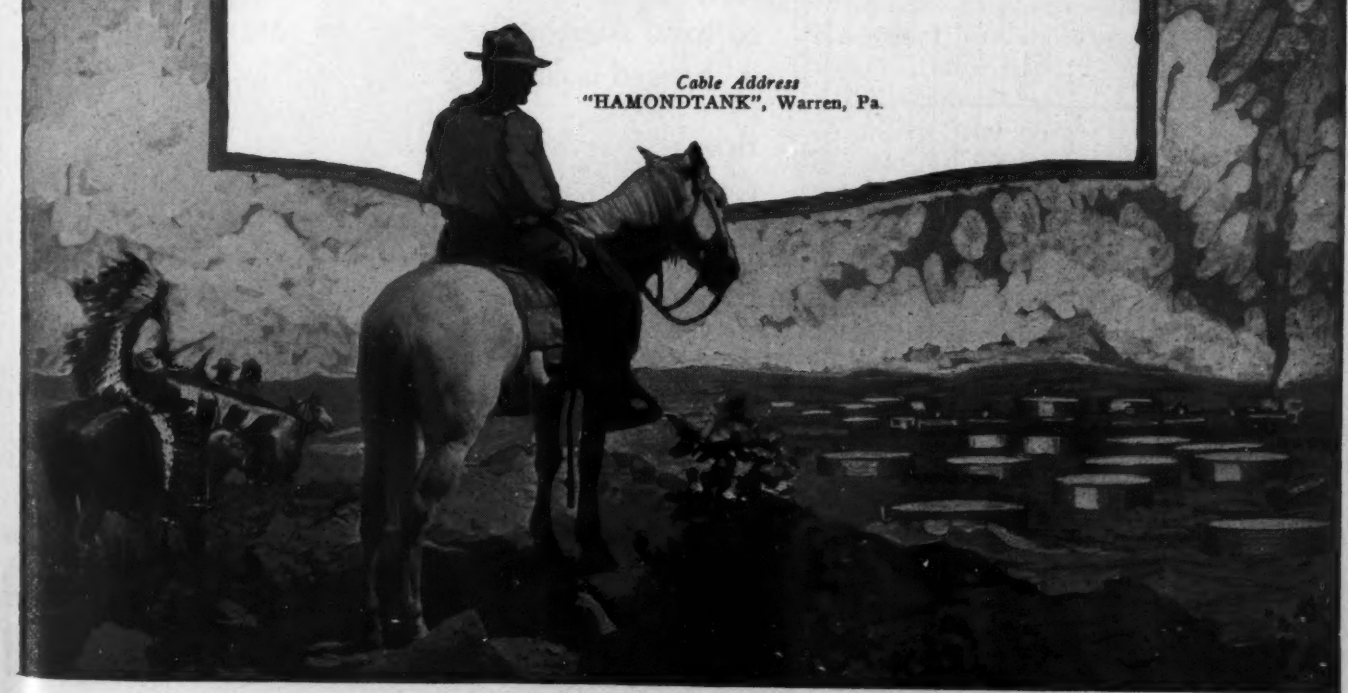


Badger Tower Reflux Control

Note on the above chart the response to changes in control setting and the small overshooting effect when under Brown Automatic Temperature Control. Need of repeated hand adjustments when the control point is changed is eliminated.

Brown Engineering Service insures satisfactory results. Let our specialists cooperate with your engineers. Write today for further data.

THE BROWN INSTRUMENT COMPANY
4498 Wayne Avenue, Philadelphia, Pa.
Branches in 20 principal cities

Brown Automatic Controls

To Measure is to Economize

Electroforged Grating!

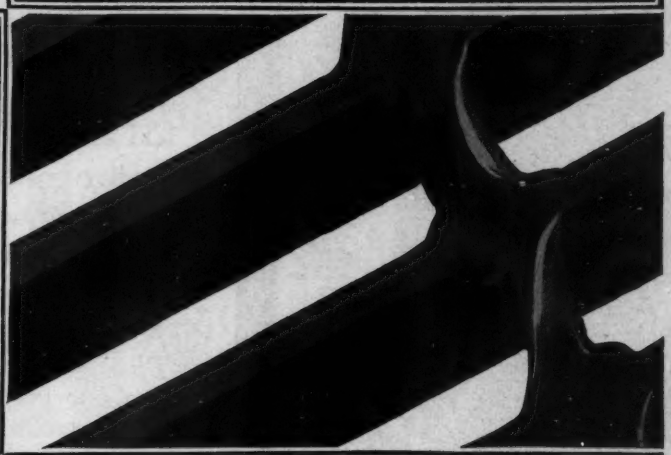
TRADE MARK REG. U.S. PAT. OFFICE
BLAW-KNOX

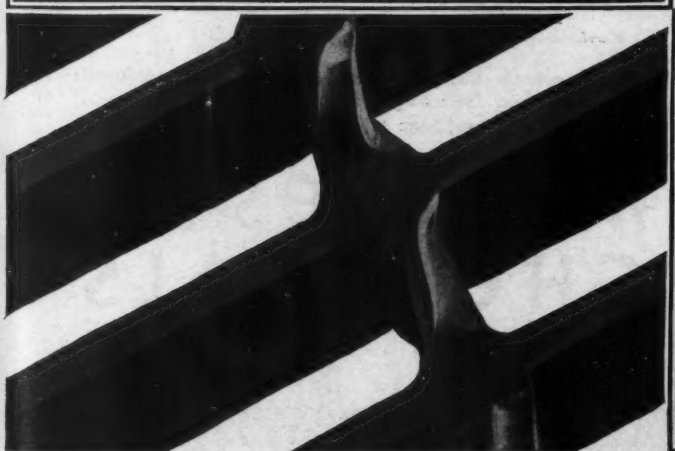
WHAT

Blaw-Knox Electroforged Steel Grating is the first and only truly *one piece* grating. Electroforged as a unit and constructed without recourse to bolts, rivets, cutting or slotting of metal. Its outstanding qualities are the noticeable absence of rattles and rigid, business-like conformation to modern engineering practice.

WHERE

Since its initial appearance in 1927 Blaw-Knox Electroforged Grating has been used by leading engineers, steel manufacturers and fabricators, contractors, subway constructors and industry in general wherever grating is requisite for open floors, stairways and runways.





WHY

Blaw-Knox Electroforged Grating and Treads have gained widest use and engineering approval because of:

- **One-piece Construction**
- **Greatest strength per pound of metal used**
- **Non-Slip Surface**
- **Maximum Admission of Light and Air**
- **Self-Cleaning Properties**

The most convincing argument for the superior features of Blaw-Knox Electroforged Grating is the Grating itself. If you will sign and return the coupon below, we shall be glad to send you full size sample and complete catalog without obligation.

BLAW-KNOX COMPANY
2005 Farmers Bank Bldg., Pittsburgh, Pa.
Send me a free sample and catalog of
BLAW-KNOX ELECTROFORGED GRATING

NAME .....
COMPANY .....
STREET .....
CITY ..... STATE .....

BLAW-KNOX

A Structure can be no stronger than its FOUNDATIONS

By CARL R. MILLER

No. 6 in a series of advertisements describing the position of The Mathieson Alkali Works in the chemical industry

WHERE plodding oxen once came for a cart of precious salt...today a modern Mathieson plant produces tons of useful chemicals needed for Industry's mills and factories. Near mighty Niagara, unharnessed for ages...today a Mathieson plant extracts power from the falls and elements from air and minerals, transforming them into chemical products that protect the lives of millions...products which cost no more yet serve better.

These modern miracles would have been impossible without strong foundations of Resources, Research and Service...foundations laid in the pioneer days of the chemical industry. That is why Mathieson chemicals represent quality born of seasoned experience...that is also why Mathieson service assures satisfaction to every purchaser.

A list of available literature describing the many uses of Mathieson chemicals will be sent on request.

The MATHIESON ALKALI WORKS (*Inc.*)
250 PARK AVENUE NEW YORK, N. Y.
PHILADELPHIA CHICAGO PROVIDENCE CHARLOTTE CINCINNATI
Works: Niagara Falls, N. Y.—Saltville, Va.
Warehouse Stocks at all Distributing Centers

Soda Ash...Caustic Soda...Bicarbonate of Soda...Liquid Chlorine...HTH (Hypochlorite)...Ammonia, Anhydrous and Aqua...Bleaching Powder...Sulphur Dichloride...PURITE (Fused Soda Ash)

MATHIESON CHEMICALS

SERVICE
RESOURCES | RESEARCH
Great Structures Rest on Strong Foundations

The OUTLET VALVE *that gives you freedom*

FROM—

losses at loading racks and in transit, complaints from buyers and the red tape of shortage claims. Young Valves open easily and seal bottle-tight.

Install Young Valves in your tank cars or request Young Valve equipped cars when ordering on track. Ask for bulletin.

HILLS-McCANNA CO.
2357 Nelson St.
CHICAGO

The YOUNG VALVE
TANK CAR BOTTOM OUTLET

for OLD *or* NEW CARS

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MINNESOTA, *Minneapolis*,
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PENNSYLVANIA, *Pittsburgh*,
Pittsburgh Supply Co.
PENNSYLVANIA, *Reading*,
Reading Foundry & Supply Co.
PENNSYLVANIA, *York*,
The Careva Company
RHODE ISLAND, *Providence*,
Read & Lundy, Inc.
SOUTH CAROLINA, *Charleston*,
Allen & Webb Co.
SOUTH CAROLINA, *Columbia*,
Columbia Supply Co.
SOUTH CAROLINA, *Greenville*,
Greenville Textile Supply Co.
TENNESSEE, *Memphis*,
Reed & Doecker
TENNESSEE, *Nashville*,
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TEXAS, *Beaumont*,
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TEXAS, *Corpus Christi*,
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TEXAS, *Dallas*,
The Murray Co.
TEXAS, *El Paso*,
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TEXAS, *San Antonio*,
San Antonio Machine & Supply Co.
TEXAS, *Waco*,
San Antonio Machine & Supply Co.
VIRGINIA, *Lynchburg*,
Gorman L. Burnett, Inc.
VIRGINIA, *Norfolk*,
Empire Machinery & Supply Corp.
VIRGINIA, *Richmond*,
Southern Ry. Supply Co.
VIRGINIA, *Roanoke*,
Gorman L. Burnett, Inc.
WASHINGTON, *Seattle*,
Craigin & Co.
WASHINGTON, *Spokane*,
Consolidated Supply Co.
WISCONSIN, *Milwaukee*,
W. H. Pipkorn Co.
WISCONSIN, *Superior*,
The Speakes Company

Canadian Distributors

BRITISH COLUMBIA, *Vancouver*,
B. C. Equipment Co., Ltd.
MANITOBA, *Winnipeg*,
Railway & Power Engrg. Corp.
NOVA SCOTIA, *Sydney*,
Railway & Power Engrg. Corp.
ONTARIO, *Hamilton*,
Thomson-Gordon, Ltd.
ONTARIO, *Port Arthur*,
Wells & Emmerson
ONTARIO, *Toronto*,
Railway & Power Engrg. Corp.
QUEBEC, *Montreal*,
Railway & Power Engrg. Corp.

Foreign Distributors

ENGLAND, *London*,
Refinery Products, Ltd.
FRANCE, *Paris*,
Compagnie Technique des Petroles
HAWAII, *Honolulu*,
Perine Machinery Co.
NEW ZEALAND, *Auckland*,
Wilton Furnace & Coal Co., Ltd.

*Billy Patterson Knew How

MODERN counterparts of the famous mixer, Billy Patterson, are the men who make and mix ADAMANT Fire Brick Cement. Provided with the most modern and efficient mixers and other equipment, the skilled makers of ADAMANT know how to produce the exceptional plasticity and uniformity that have always been characteristic of ADAMANT Fire Brick Cement.

Properly and thoroughly mixed before shipment, ADAMANT comes to you in "wet" (plastic) form, ready-mixed and ready for use. You save the time and labor of hand-mixing on the job that would be required with cements shipped to you in "dry" form. And you get better results from your fire brick construction.

ADAMANT enables the mason to make *thinner* joints that *bond better . . . tighter . . . firmer* and *more permanently* whether dipped, buttered or spread. It is very definite assurance of long-lasting, trouble-free fire brick construction. May we send you complete data on ADAMANT and other ADAPRODUCTS? Write us.

Every one of our factory representatives is equipped with a Pyro Radiation Pyrometer which gives instant, accurate reading of the temperature in any or all parts of the furnace.

*

Only the "old-timers" will remember Billy Patterson, of "Who struck Billy Patterson?" fame. A wizard with the shaker, his concoctions earned him a host of admirers and a national reputation.

BOTFIELD REFRACTORIES CO.
World's Largest Exclusive Manufacturer of High Temperature Cements
Swanson and Clymer Streets, Philadelphia, Pennsylvania

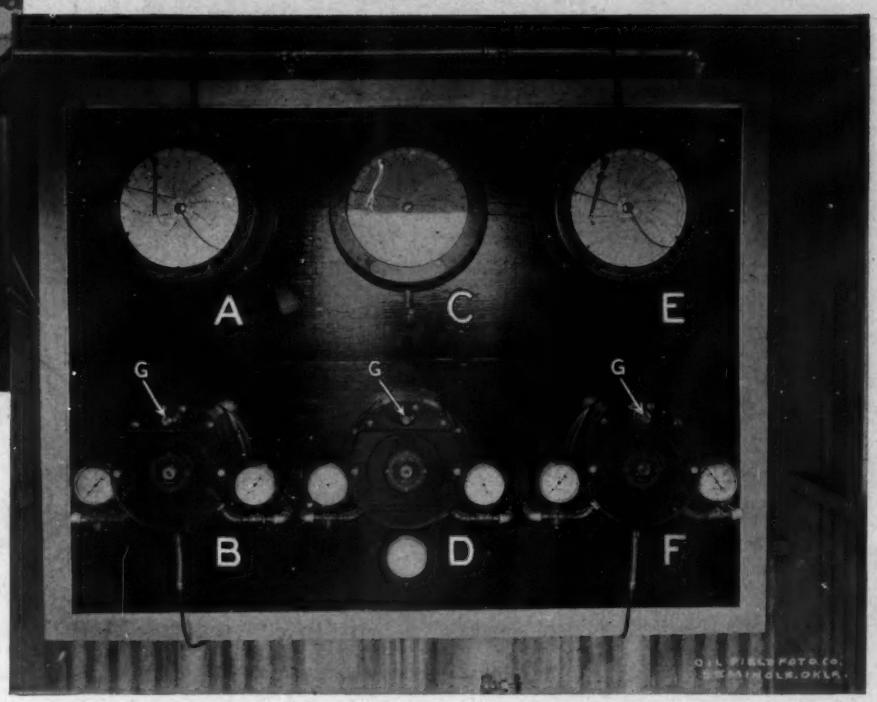
ADAMANT
FIRE BRICK CEMENT

Other ADAPRODUCTS Include
ADACHROME Plastic Super-Cement
ADACHROME *Fines* ADACHROME *Aggregate*
ADAPATCH (fire brick in plastic form)
The ADAMANT Gun

Write for booklet

Controlled Operation

Paves The Way To Greater Economy!



Above: Stabilizer Column at Natural Gasoline Plant of large Oklahoma Oil Company.

At right: Bristol's Instrument Equipment installed to automatically control Stabilizer Temperature and Pressure. Below is detailed description:

◆

A—Model 241 Bristol's Recording Thermometer; using 8-inch, 24-hour chart, with range 30-160° F. Provides constant check on Stabilizer Top Temperature.

B—Series 101 Bristol's Air Operated Temperature Controller (Reverse Acting). Range 50-150° F. Operates to maintain Uniform Top Temperature.

C—Model 41 Bristol's Recording Gauge; using 8-inch, 24-hour chart, with scale 0-300 pounds. Shows Back Pressure maintained.

D—Series 350 Bristol's Air Operated Pressure Controller; Range 75-300 pounds. Provides check on Stabilizer Bottom Temperatures.

E—Model 241 Bristol's Recording Thermometer; using 8-inch, 24-hour chart, with range 30-250° F. Provides check on Stabilizer Bottom Temperatures.

F—Series 100 Bristol's Air Operated Temperature Controller (Direct Acting). Range 150-275° F. Controls Bottom Temperature.

G—Controller Air Valve—(which might be termed the heart of the Control System)—is instantly accessible for cleaning, inspection, or replacement. To remove, simply unscrew and lift out valve with spring attached. The valve seat is then exposed, almost flush with front of instrument case. To replace, just screw in again—no further adjustment required.

THE improvement of Product Quality . . . saving in operating time . . . reduction in fuel and labor costs, etc., being attained through use of Recording and Automatic Control Instruments has aroused widespread interest among Oil and Gas Industry Engineers. Shown in the accompanying illustration, for example, are Bristol's Air Operated Temperature and Pressure Controllers; together with Recording Thermometers and Gauges installed in the Natural Gasoline Plant of a large Oklahoma Oil Company. (See detailed description elsewhere on this page).

This is but one instance of how Bristol's Instruments can be adapted to meet Oil and Gas Industry requirements. The complete line offers both Recording and Indicating Types of Gauges, Thermometers, Pyrometers, etc., together with a complete assortment of Electrical or Air Operated Pressure and Temperature Controllers, and Controller Valves.

Bristol's Field Engineers will be pleased to call at your convenience and describe in detail any type of instrument equipment in which you are interested. For conference or more complete information, write direct to main office at Waterbury, Connecticut, or nearest branch office.

THE BRISTOL COMPANY, Waterbury, Connecticut

BRANCH OFFICES
Boston
New York
Philadelphia
Pittsburgh
Birmingham
Detroit

BRISTOL'S
SINCE 1889
Instruments *for* Indicating Recording Controlling

BRANCH OFFICES
Chicago
Akron
Denver
St. Louis
Los Angeles
San Francisco

ANNOUNCING the OHIO Type A-1 RETURN BEND !

. . . . offering YOU New Service

It's just off the press . . . an Ohio Bulletin, giving full information on a new return bend . . . one that overcomes all return bend troubles.

Send for this interesting data . . . it explains fully the ingeniously designed, flexible interior that *automatically* assumes the stress and strain of expansion and contraction.

Here, also, is full guarantee against corrosion . . . a one-piece, free-flow passage that does not allow oil to seep or clog . . . less down-time than ever before!

You will be interested in the way the tubes are fitted . . . by this new feature one tube can be replaced without disturbing another.

Easier assembly, less friction, finer construction, and fewer parts all go together to make a return bend that you will want . . . send for the new bulletin today . . . here is *real* news!

The Ohio Steel Foundry Co.
Springfield, Ohio

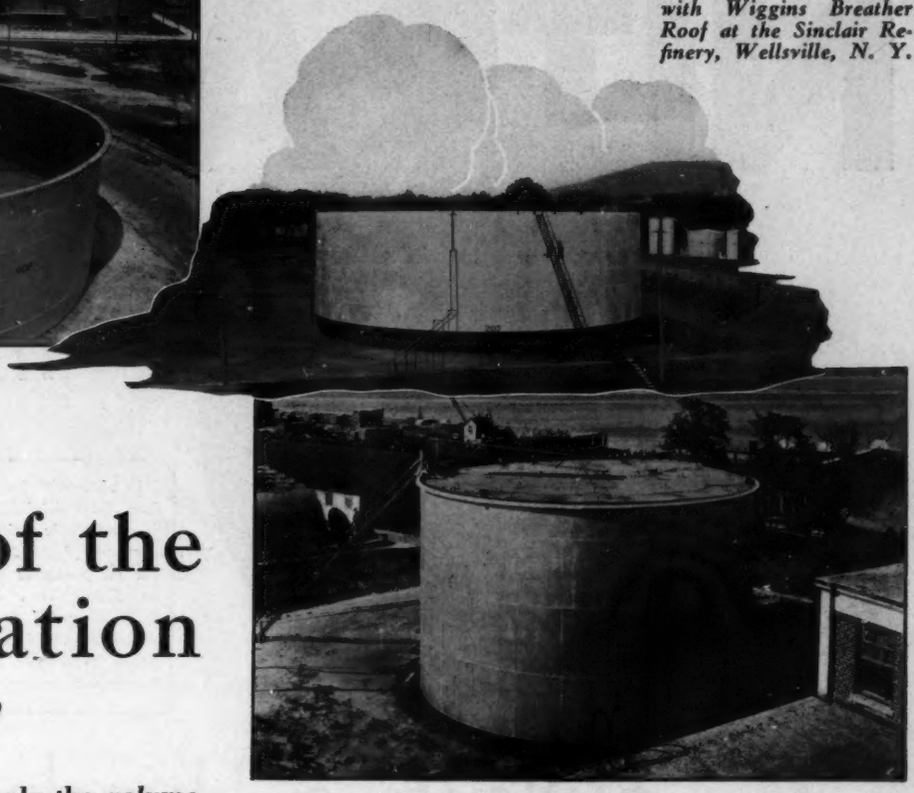
SALES OFFICES
Chicago....1313 Peoples Gas Bldg.
Houston....410 Union Nat'l Bank
Los Angeles...2800 S. Alameda St.

Plants In
Lima, Ohio - Springfield, Ohio
Bay City, Mich.

SALES OFFICES
Philadelphia.....22 So. 15th St.
Cleveland..1510 Term. Tower Bldg.
New York.....75 West St.
Tulsa.....422 Wright Bldg.

Left: Wiggins Floating Roof on tank at refinery in Port Arthur, Texas.

Storage tank equipped with Wiggins Breather Roof at the Sinclair Refinery, Wellsville, N. Y.



The "gravity" of the oil evaporation situation—

Wiggins Pontoon Roof on 25,000 barrel Horton Tank — Pan American Petroleum & Transport Corporation, Jacksonville, Florida

EVEN if Wiggins Roofs saved only the *volume* of oil lost by evaporation, they would be a highly profitable investment.

But evaporation studies prove that the *total* loss to the refiner (volumetric plus gravity) may be more than twice the volumetric loss. For example: with $1.50 crude and 5 cents differential per degree A.P.I. a 1% volumetric loss means a total value loss of 2-1/3%. This of course is due to the fact that evaporation takes out of the tank only the lightest and most valuable fractions of the oil. What remains is not as high in gravity as it was before.

On rundown and other working tanks, the Wiggins Floating Roof stops both breathing losses and filling and emptying loss. The deck floats on the oil, blanketing it at all levels. Oil in the annular space between the deck and tank shell is kept out of contact with air by an effective seal.

The Wiggins Breather Roof, for standing storage tanks, is fastened to the top angle of the shell and flexes up and down to accommodate thermal "breathing" of the tank contents. Vapor is not vented out, nor air drawn in.

The accompanying table shows the savings possible in stopping volumetric and gravity loss with both types of Wiggins Roofs. They are also extensively used for eliminating fire hazard and for minimizing sour oil corrosion. Write our nearest office for full information and quotations.

ANNUAL SAVINGS WITH WIGGINS ROOFS
WORKING TANKS

Bbls. Pumped Daily	Kind of oil	Cone Roof Tank Loss	Floating Roof Loss	Saving in Dollars
5,000	Gasoline	3,250-4,855	155	$13,000-$19,800
10,000	Gasoline	6,500-9,710	300	26,000- 39,600
5,000	Crude	1,810-2,310	110	5,950- 7,700
10,000	Crude	3,000-4,500	150	9,975- 15,225

STANDING STORAGE

Tank Dia. in ft.	Kind of oil	Cone Roof Tank Loss	Breather Roof Loss	Saving in Dollars
120	Gasoline	950-1,200	20-50	$4,368
60	Gasoline	200- 300	10-25	966
120	Crude	500- 600	10-25	1,855
90	Crude	300- 350	10-25	1,067

CHICAGO BRIDGE & IRON WORKS

Dallas . . . . . 3355 Magnolia Bldg.
Houston . . . . . 1126 Electric Bldg.
Tulsa . . . . . 2426 Exchange Bank Bldg.
Birmingham . . . . . 1548 Fiftieth St., N.
Atlanta . . . . . 2146 Rhodes-Haverty Bldg.
Chicago . . . . . 2463 Old Colony Bldg.
Detroit . . . . . 1520 Lafayette Bldg.
Cleveland . . . . . 2234 Midland Bank Bldg.
New York . . . . . 3102 Hudson Terminal Bldg.
Philadelphia . . . . . 1608 Jefferson Bldg.
Boston . . . . . 1529 Consolidated Gas Bldg.
San Francisco . . . . . 1051 Rialto Bldg.
Seattle . . . . . 4312 Smith Tower
Havana, Cuba . . . . . Apartado 2507

WIGGINS ROOFS

R-12 Gray

The NITRALLOY movement of this Gauge

The Ashcroft American DURAGAUGE is made in sizes from 4½" to 16", for all pressures up to 5,000 lbs., in Wall Mounted case, Flush Mounted and Flush Mounted Illuminated cases.

. . . outlasts a Hundred others

SIX months ago the nitralloy movement of one of our new Ashcroft American DURAGAUGES was connected to a small compressed air hammer vibrating at about 1500 cycles per minute. At the same time the movement of a commercial gauge was attached to the same hammer in the same way.

The hammer has been vibrating 24 hours a day ever since. The nitralloy movement still shows no sign of wear, but the other gauge movement has been replaced successively by a hundred others . . . . including movements taken from every make of gauge. The average length of life of an ordinary bronze movement was 75 minutes under this severe test. By that time the teeth were worn almost bare.

These movements have, in every instance, literally gone to pieces before being replaced . . . . but the new Ashcroft American nitralloy movement remains in perfect condition.

Frankly, we don't know how long it *will* last! But consider what this means to you . . . . here at last is a gauge with a practically indestructible movement; a gauge that is made to last forever.

The Ashcroft American DURAGAUGE is unconditionally guaranteed for five years, and to be accurate within one-half of 1% over the entire scale range. Such a gauge could only be produced by a Company with a background of eighty years of gauge manufacturing experience. Write today and get the complete story.

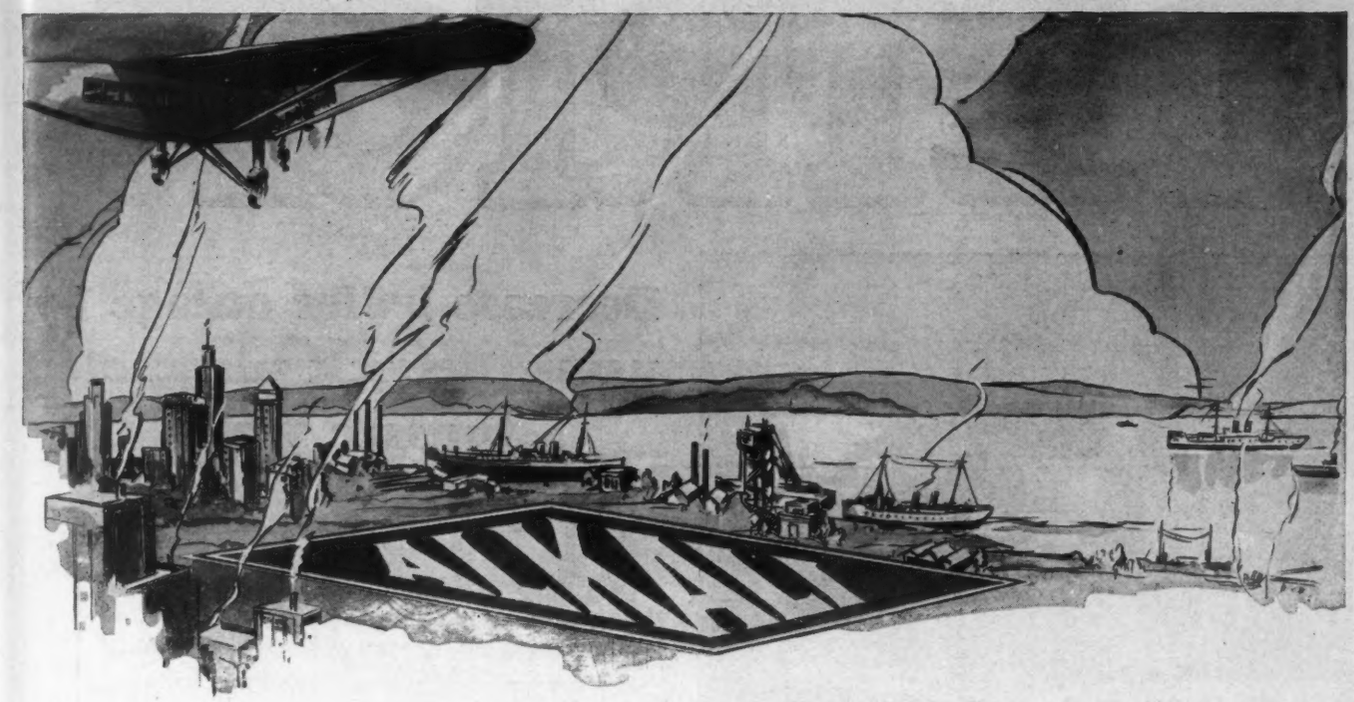
CONSOLIDATED ASHCROFT HANCOCK CO., INC.
Bridgeport, Conn.
Subsidiary of Manning, Maxwell & Moore, Inc.

CONSOLIDATED ASHCROFT HANCOCK

ASHCROFT AMERICAN DURAGAUGE

Specify Catalogs Desired:

American Dial Thermometers	G-19	American Recording Gauges	E-19	Consolidated American Safety and Relief Valves	Z-19
American Glass Thermometers	F-19	American Draft Gauges	B-19	Hancock Bronze Valves	WB-19
American Recording Thermometers	H-19	American Gauge Testers	D-19	Hancock Cast Steel Valves	WA-19
Ashcroft American Gauges	A-19	American Tachometers	J-19	Hancock Forged Steel Valves	W-19
American Temperature Controllers	R-19	Ashcroft Power Control Valves	M-19		



The Refining Industry's Unmistakable Guide

When the Caustic Soda buyer is lost in a fog of indecision . . . when the refining industry seeks a brand of Caustic Soda which they know will test *over* 76% by actual analysis . . . when quality, purity and unvarying uniformity are demanded . . . then Diamond Brand is the unmistakable guide to lasting satisfaction.

Diamond 76% Caustic Soda enjoys a nation-wide confidence established by many years of service. The high quality originally established has been rigidly maintained by the most scientific manufacturing methods.

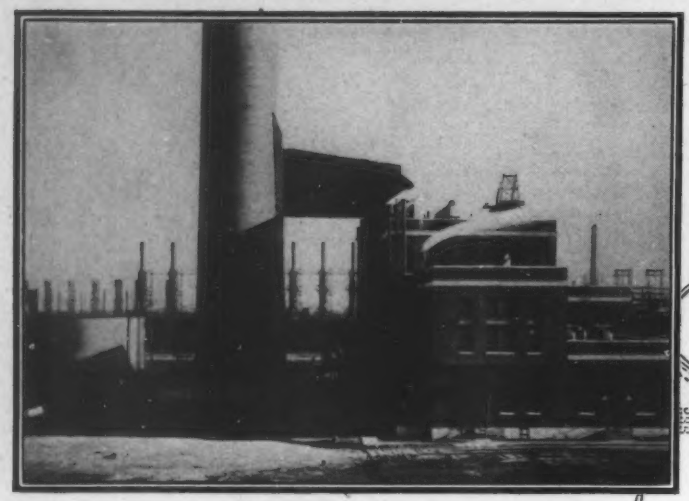
When purchasing Caustic Soda specify 76% actual test—*there is a difference.*

Diamond Alkali Company

Pittsburgh, Pa., *and Everywhere*

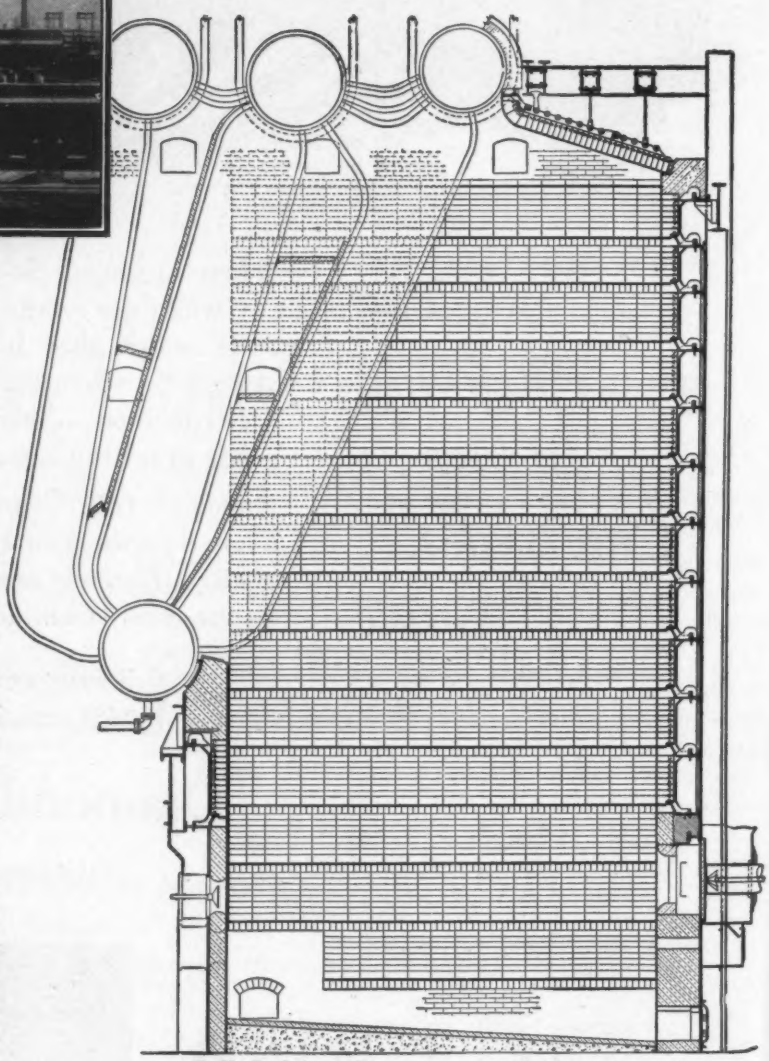
Southwest Representative
FRED W. FRALEY, Jr.,
1006 Main St., Houston, Texas

DETRICK



Gulf Refining Co., Port Arthur, Texas
United Engineers & Constructors, consultants

Decrease boiler outage by using Detrick air cooled furnace walls



Gulf Refining Company assured themselves of decreased boiler outage by using Detrick air cooled walls with every refractory tile anchored in place.

TWO IMPORTANT FACTS

1. The disintegrating forces of boiler vibration, and refractory expansion and contraction, are powerless to affect Detrick arch and wall construction. Because—every Detrick refractory tile is securely anchored in place.

2. When firing is so severe that ultimately even air cooled tile are burned away, the Detrick tile remain efficiently in service to the last inch of their effective depth. Because—every Detrick refractory tile is securely anchored in place.

M. H. DETRICK CO., 140 S. Dearborn St., Chicago, Ill.

NEW YORK 50 Church St. | PHILADELPHIA Morris Bldg. | PITTSBURGH Empire Bldg. | DETROIT Penobscot Bldg. | SAN FRANCISCO Russ Bldg.

Sales Engineers in other principal cities.

DETRICK ARCHES & WALLS

"Better than the Refractory of which They are Made"

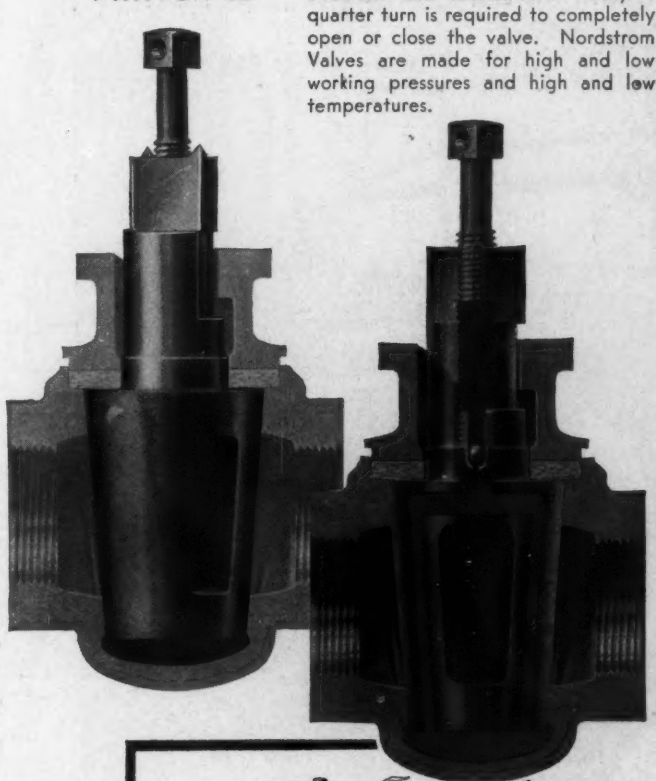
R12-Gray

Hydraulic valve lubrication insures effective manipulation

High pressure lubrication prevents valve leakage by application of the Nordstrom principle. Nordstrom Valves prevent leaks and stay tight after long service. A force several times that of the line pressure is used to force viscous "Merco" lubricant into every pathway of leakage, thereby sealing the valve effectively from further leakage. The seat and plug surfaces are renewed completely by making use of the proper lubricants. At the same time pressure lubrication performs the other functions of a hydraulic jack when necessary to loosen the plug when stuck and so reduces the coefficient of friction on sliding metal surfaces held together under high pressure. Furthermore, Nordstrom Valves effectively combat corrosion and erosion when used as a stop in the pipe line. None of the vital parts are exposed to disintegrating forces of the fluid. We strongly recommend the use of "Merco" lubricants. Ask for Catalog.

THE PERFECT APPLICATION OF A PRINCIPLE

The phantom views shown below illustrate the plug cock principle of construction and lubrication. Only a quarter turn is required to completely open or close the valve. Nordstrom Valves are made for high and low working pressures and high and low temperatures.



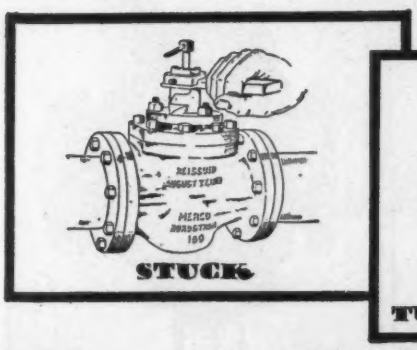
MERCO NORDSTROM VALVE COMPANY
SUBSIDIARY OF THE MERRILL COMPANY . . ENGINEERS

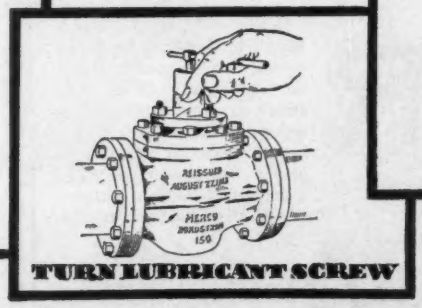
Atlanta - Healy Bldg.
Boston - 184 Boylston St.
Buffalo - Genesee Bldg.
Charleston - 304 Capitol St.
Chicago - 176 W. Adams St.
Dallas - Magnolia Bldg.
Detroit - 2842 West Grand Blvd.
El Paso - 111 So. Virginia St.
Houston - Petroleum Bldg.
Los Angeles - 656 So. San Pedro St.
New Orleans - Masonic Bldg.
NewYork - 11 W. 42nd St.
Pittsburgh - Clark Bldg.
St. Louis - 317 N. Eleventh St.
San Francisco - 343 Sansome St.

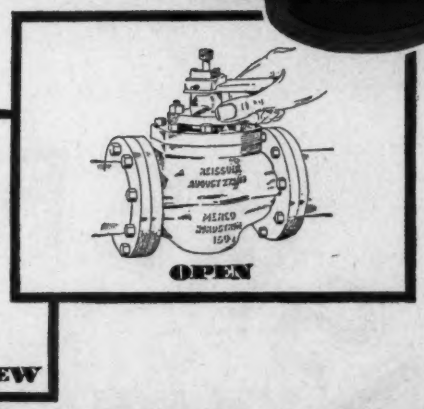
Agencies:

Denver - Republic Supply Company, 332 Continental Oil Bldg.
Honolulu - W. A. Ramsay Co., Ltd., Fort & Queen Streets
Manila - E. W. Sharp, c-o J. A. Murphy Co. Peres Semanillo Bldg.
Philadelphia - Brown, Wilson & Company, 1600 Arch St.
Saginaw - Arthur C. Beckert, 112 Durand St.
Salt Lake City - National Equipment Co., 101 West 2nd South St.
Tulsa - B.V. Emery & Company, 216 E. Brady Street

Factories in U. S. Oakland, Calif. and Belleville, N. J.
Canada - Peacock Bros., Ltd., Montreal, Toronto, Winnipeg, Vancouver. (Also Sydney, N.S.)
England - Audley Engineering Co., Ltd., Newport, Shropshire.
Buenos Aires, Argentine, - General Electric, Soc. Anon., Victoria 618 Esq. Peru.

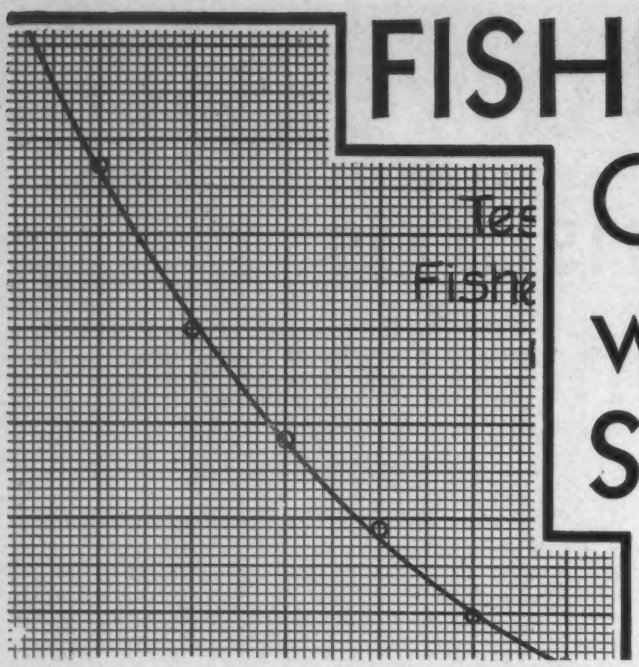






MERCO

Nordstrom Valves



FISHER Capacity Charts show where you can SAVE money

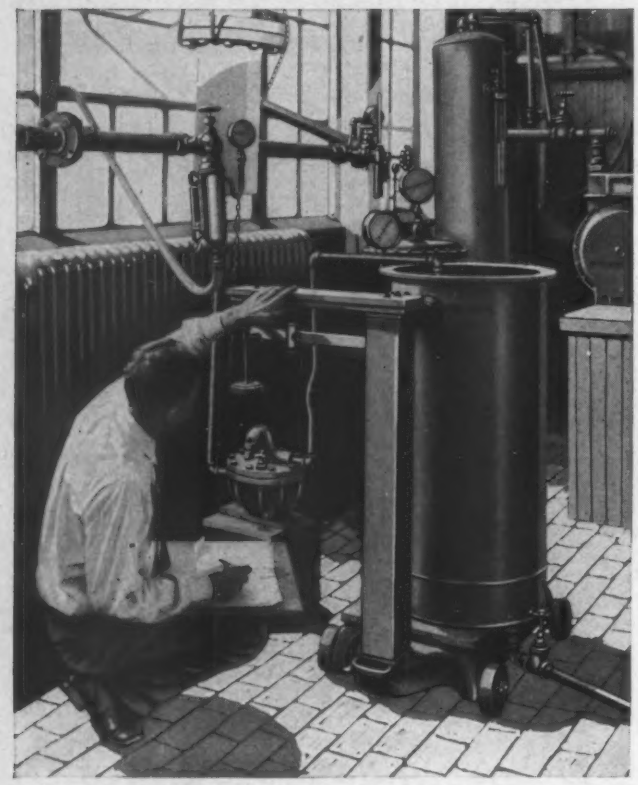
AN ENGINEER who uses many types of fluid control specialties told us this: "Since I have been using your capacity charts, I have discovered that the pressure governors, liquid level controllers, etc., I previously installed were all considerably oversize. Whenever I specified a specialty, I always stepped it up a size, because I knew the rated capacities were just estimates and I wanted to be sure it would be large enough.

"Now that I have these charts I am saving considerable money by specifying the smaller sizes that your tests prove will do the job." He might have added that more accurate control and longer life are also assured when the valve is working close to capacity.

Fisher Capacity Charts are taken from comprehensive scientific tests of each size and type of valve—they have nothing to do with the usual theoretical estimated capacities. The charts for steam, air, gas and liquids will now be gladly sent upon request to users of Fisher Specialties; they, of course, are applicable only to Fisher Specialties.

THE FISHER GOVERNOR COMPANY

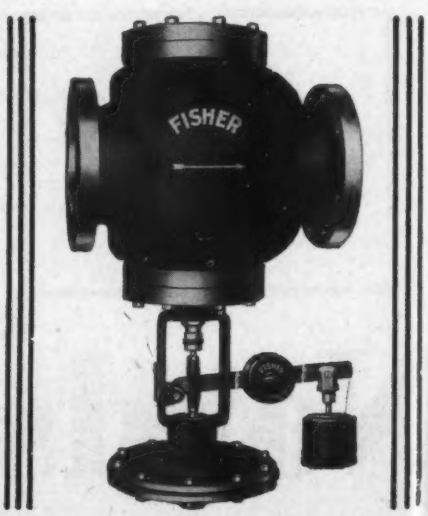
1300 Fisher Building **Marshalltown, Iowa**



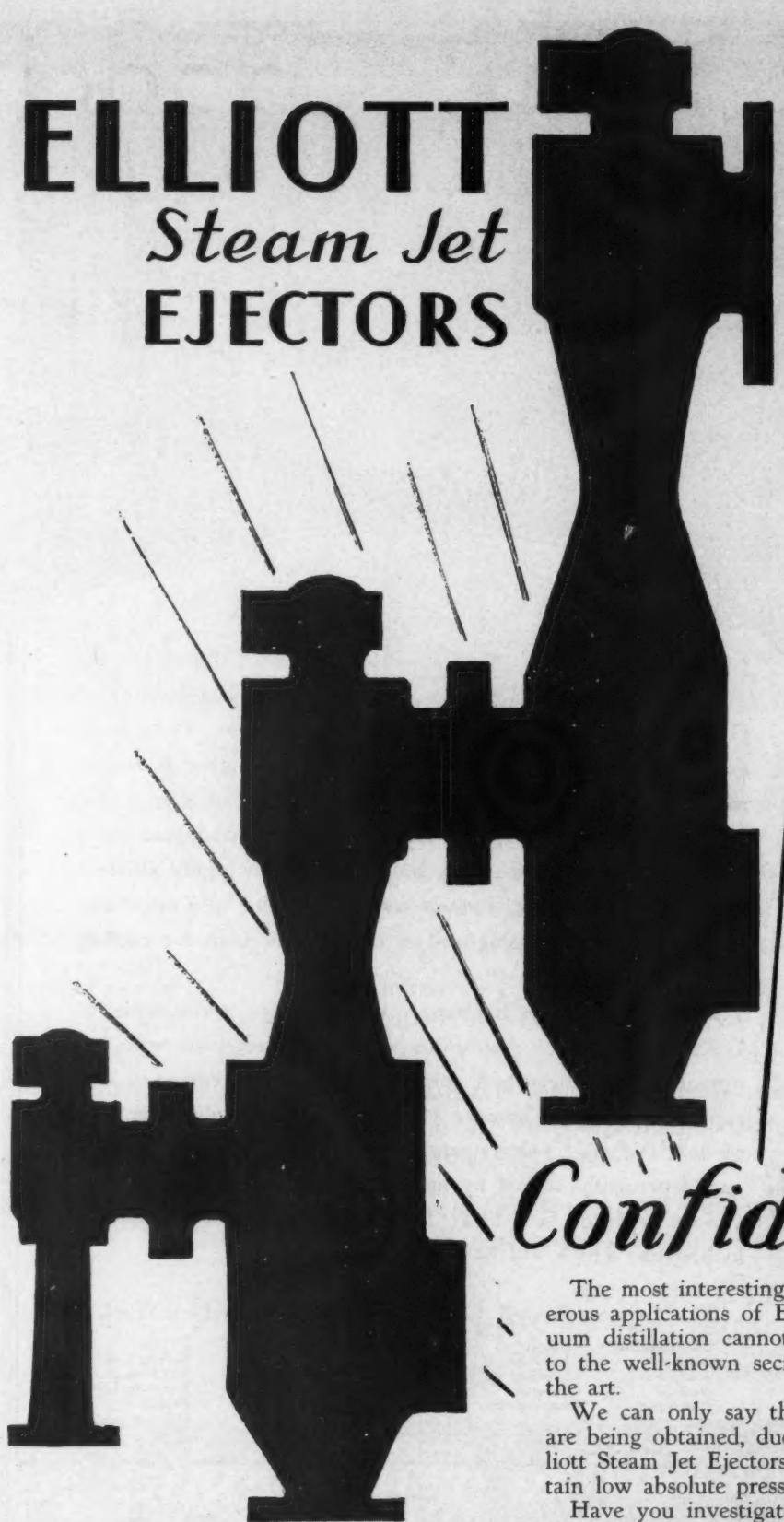
FISHER

THE MARK OF SCIENTIFIC FLUID CONTROL

The Fisher Type 10-A Pressure Regulator is widely used for reducing the pressure of steam, air, oil and other fluids. It is particularly well suited to low reduced pressure service. It is simple in design and dependable in operation—there are no pistons and no dashpots to stick as a result of scale or corrosion.



ELLIOTT
Steam Jet
EJECTORS



Confidential

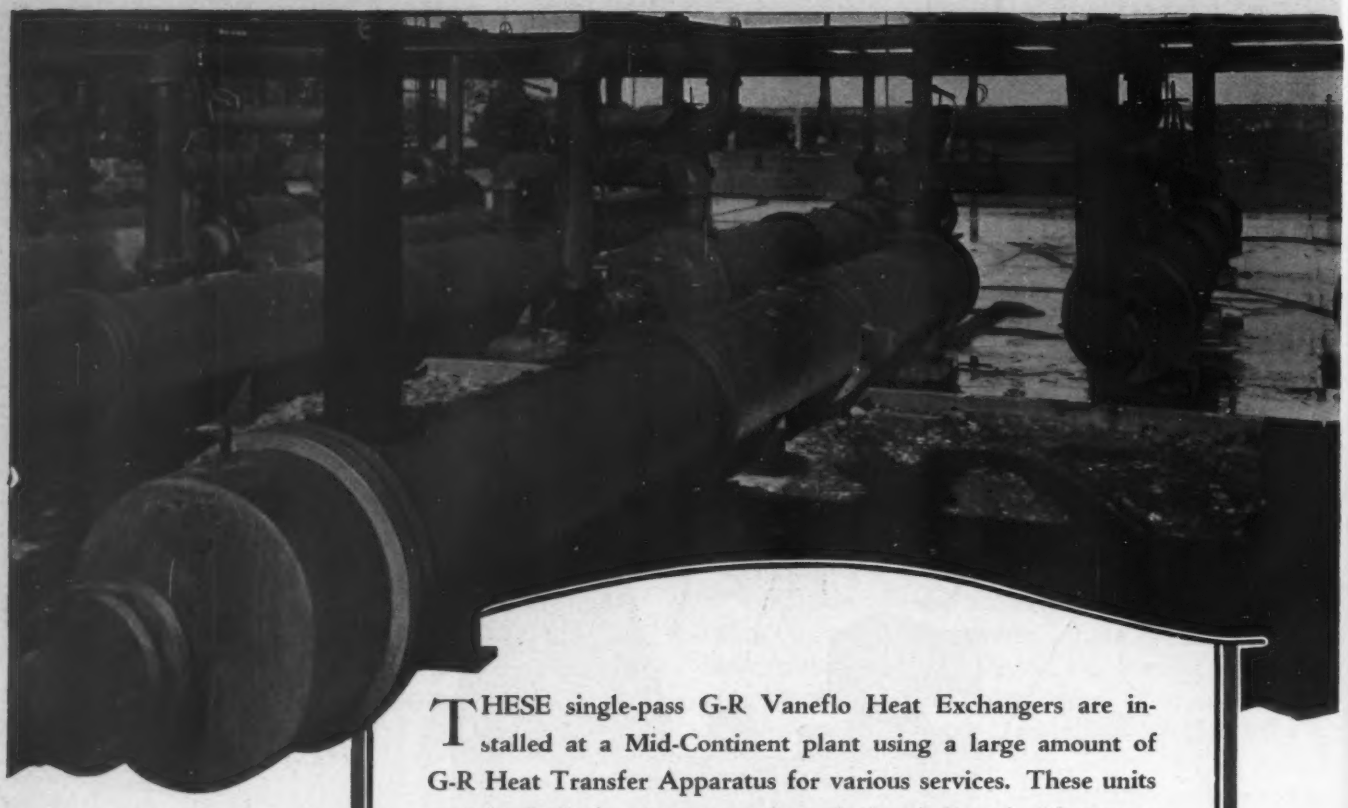
The most interesting facts about the numerous applications of Elliott Ejectors to vacuum distillation cannot be made public due to the well-known secrecy which surrounds the art.

We can only say that remarkable results are being obtained, due to the ability of Elliott Steam Jet Ejectors consistently to maintain low absolute pressures.

Have you investigated the possibilities of high vacuum operation? Let us help you.

ELLIOTT COMPANY
PITTSBURGH, PA.

Industrial Process Dept.
JEANNETTE, PA.
Branch Offices in Principal Cities



THESE single-pass G-R Vaneflo Heat Exchangers are installed at a Mid-Continent plant using a large amount of G-R Heat Transfer Apparatus for various services. These units are also built for two-passes through the shell and with two or more passes through the tubes. This flexibility of design and their many additional special features make them adapted for a wide range of services. They have been found highly efficient on handling residuum, mineral seal oil, gasoline and other distillates, crude, and casinghead or natural gas, both for cooling and heat exchange.

The Vaneflo Heat Exchanger is one of the many types of G-R Heat Transfer Apparatus which have received wide approval from refinery and natural gasoline plant engineers and superintendents. Whatever your condensing, cooling, heating or heat exchange requirements may be, they can be efficiently and dependably served by an exactly suitable G-R unit. The various types of G-R Heat Transfer Apparatus are described in bulletins which will be sent on request.

The shells of all G-R Heat Transfer Apparatus are welded by the G-WELD Process.

HEAT EXCHANGERS
CONDENSERS
Sub-cooling—Partial—Reflux
Shell-and-Tube, Atmospheric, and Condenser Box Types
COOLERS
Liquid—Gas—Jacket Water
Shell-and-Tube, Atmospheric, and Condenser Box Types
OIL HEATERS
LEVEL CONTROLLERS

The Griscom-Russell Co., 285 Madison Ave., New York

Philadelphia	Chicago	Milwaukee	Memphis	Dallas
Boston	Cleveland	Detroit	Indianapolis	Kansas City
Rochester	Massillon	New Orleans	Cincinnati	San Francisco
Buffalo	St. Louis	Atlanta	Tulsa	Los Angeles
Pittsburgh	Minneapolis	Charlotte	Houston	Seattle
				Denver

For Canada: Riley Engineering and Supply Co., Ltd., Toronto

Griscom-Russell
Heat Transfer Apparatus

MALLEABLE *heat-control*

CAST IRON
Screwed—Flanged—
Drainage—Sprinkler

ELECTRIC CAST STEEL
Screwed—Flanged

MALLEABLE
Standard—Extra Heavy
Hydraulic—Oil Country
Railroad 300 lb.—Fire Line

STOCKHAM RETURN BEND
For Cracking Stills

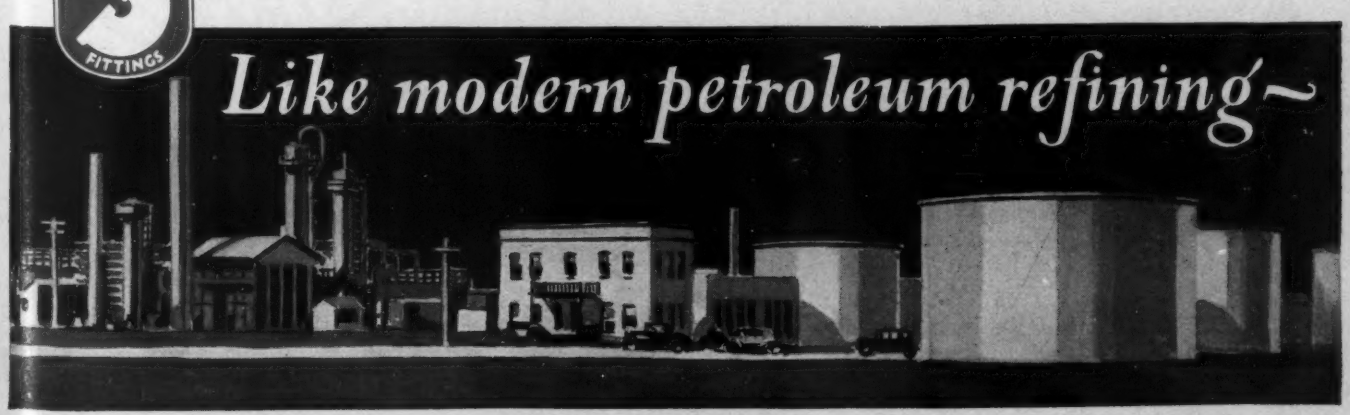
Heat-control is a vital part of the process of petroleum refining—but no less essential is heat-control in the production of malleable iron fittings for the severe service of oil field use.

The superiority of Stockham Malleables is largely due to the accurate control of the heat treatment of the metal. Skill and constant watchfulness of the battery of recording pyrometers shown in the illustration insure the outstanding strength of Stockham Malleables, which make them stand the shock, vibration and temperature changes of oil field service.

In addition to a full line of oil field malleables, Stockham Fittings are available in cast iron and electric cast steel for every petroleum field requirement.

STOCKHAM PIPE & FITTINGS CO., ***Birmingham, Ala.***

Boston, New York, Philadelphia, Chicago, Houston, Los Angeles



STANDARDS OF SERVICE IN CHEMICALS

USERS OF CHEMICALS OBTAIN A HIGHER STANDARD OF SERVICE WHEN THEY BUY HOOKER CHEMICALS. RECOGNIZED QUALITY COMBINES WITH AN UNEXCELLED TECHNICAL SERVICE AND PROMPT DELIVERIES TO PROVIDE OPERATING ECONOMIES IN THE PLANT THAT CAN ACTUALLY BE MEASURED IN DOLLARS AND CENTS.

OUR TECHNICAL AND RESEARCH STAFF, BACKED BY OVER 25 YEARS OF EXPERIENCE, IS READY TO HELP YOU IN MOST ECONOMICALLY APPLYING HOOKER CHEMICALS TO YOUR INDIVIDUAL REQUIREMENTS.

HOOKER CHEMICALS

CAUSTIC SODA LIQUID CHLORINE
BLEACHING POWDER MURIATIC ACID
MONOCHLORBENZENE
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BENZOATE OF SODA BENZOIC ACID
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ANTIMONY TRICHLORIDE
FERRIC CHLORIDE SALT
SULPHUR MONOCHLORIDE
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HOOKER ELECTROCHEMICAL COMPANY

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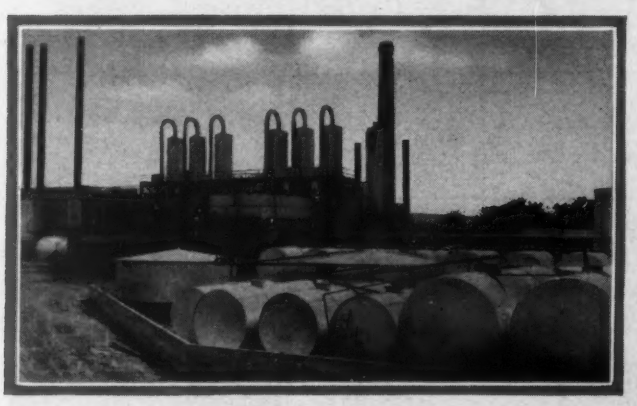
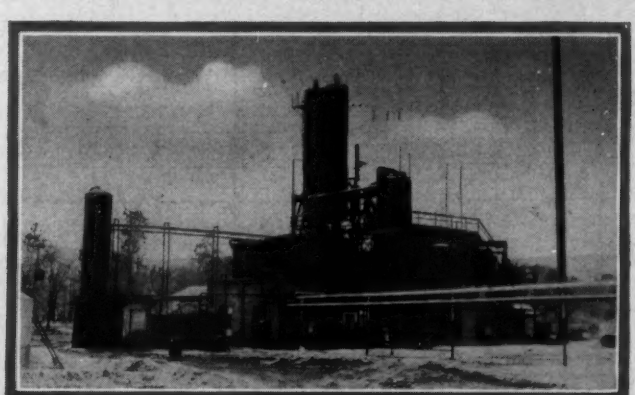
HOOKER CHEMICALS

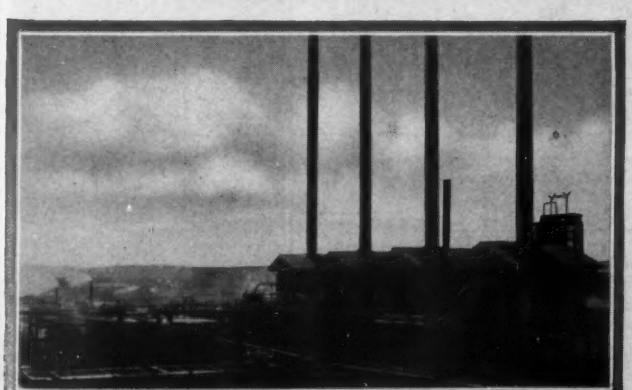
5017

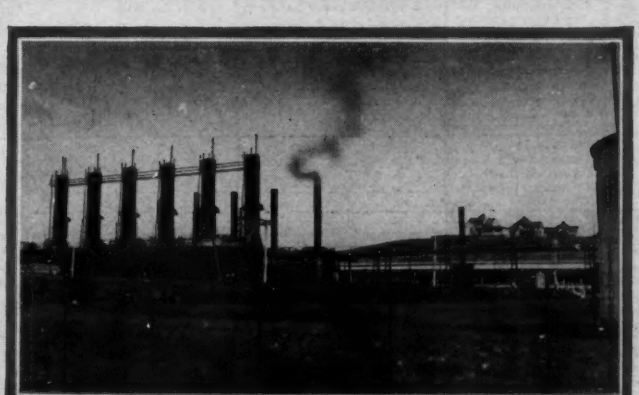
Leading Oil Refiners know there's economy in using GENERAL REFRACTORIES PRODUCTS

here are a few . . .



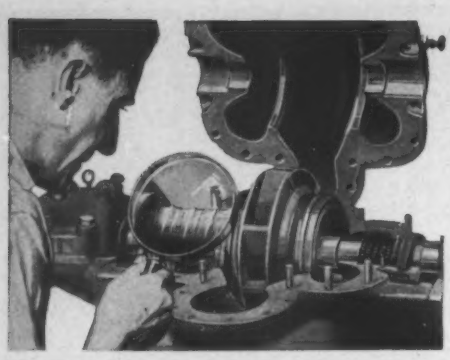






GENERAL REFRACTORIES COMPANY 106 South 16 St., Philadelphia, Pa.
Branches in principal cities

4711



Select the Packing Best Adapted to the Conditions of Service

The varied conditions under which a packing must work make it necessary that the packing be adapted to such conditions.

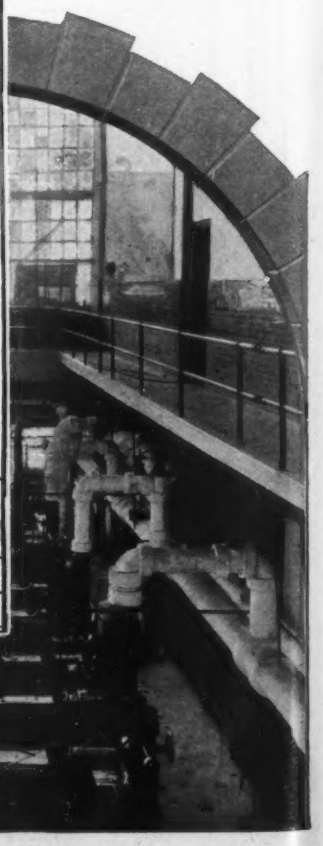
No one packing could possibly be expected to meet all conditions.

The A. B. C. of Packing		PALMETTO PACKING	CUTNO PACKING	PELRO PACKING	SQUARE PALCO PLAITED PACKING
A	Acetone			x	
	Acetic Acid (Glacial & dilute)		x		
	Alum		x		
	Ammonia (Anhydrous & dilute)		x		
	Amyl Acetate (Banana oil)			x	
B	Benzine (Benzol)			x	
	Benzoic Acid	x			
	Borax	x	x		
	Boric Acid	x			
	Bleach Liquor		x		
	Bromine		x		
	Butyl Acetate			x	
C	Calcium Brine				x
	Chlorine		x		
	Citric Acid	x			
	Compressed Air	x			
	Creosote (Coal tar)		x		
E	Ethyl Acetate (Acetic ether)			x	
	Ethyl Alcohol (Grain alcohol) (Concentrated & dilute)		x		
G	Gasoline			x	
H	Hydrochloric Acid (Muriatic)		x		
	Hydrogen Peroxide		x		
K	Kerosene			x	
L	Lactic Acid		x		
	Lime		x		
	Lime Sulphur		x		
M	Methyl Alcohol (Wood alcohol) (Concentrated & dilute)		x		
	Mineral Spirits			x	
N	Naphtha			x	
	Nitric Acid		x		
O	Oleic Acid	x			
	Oxalic Acid	x			
P	Palmitic Acid	x			
	Phosphoric Acid		x		
	Potassium Carbonate (Potash)		x		
	Potassium Cyanide		x		
	Potassium Sulphide		x		
	Potassium Hydroxide (Caustic potash)		x		
S	Sodium Bicarbonate	x			
	Sodium Cyanide		x		
	Sodium Carbonate (Soda ash)		x		
	Sodium Hydroxide (Caustic soda)		x		
	Sodium Bisulphite		x		
	Sodium Silicate (Waterglass)		x		
	Sodium Sulphite	x	x		
	Sodium Sulphide		x		
	Sulphuric (Oil of vitriol)		x		
	Sulphurous		x		
	Salt Cake		x		
	Stearic Acid	x			
	Steam (High pressure, superheat)	x			
T	Tannic Acid	x			
	Tartaric Acid	x			
	Toluene (Toluol)			x	
	Tri-sodium Phosphate		x		
	Turpentine			x	
W	Water (Hot & Cold)				x
X	Xylene (Xylol)			x	

SEND FOR THIS CHART AND HANG IT UP FOR REFERENCE

COMPRESSED AIR

The high temperature of Compressed Air requires the great heat-resisting quality and perfect lubrication of "PALMETTO" PACKING, which gives longer and more satisfactory service under compressed air and high-pressure super-heated steam than any other packing on the market.

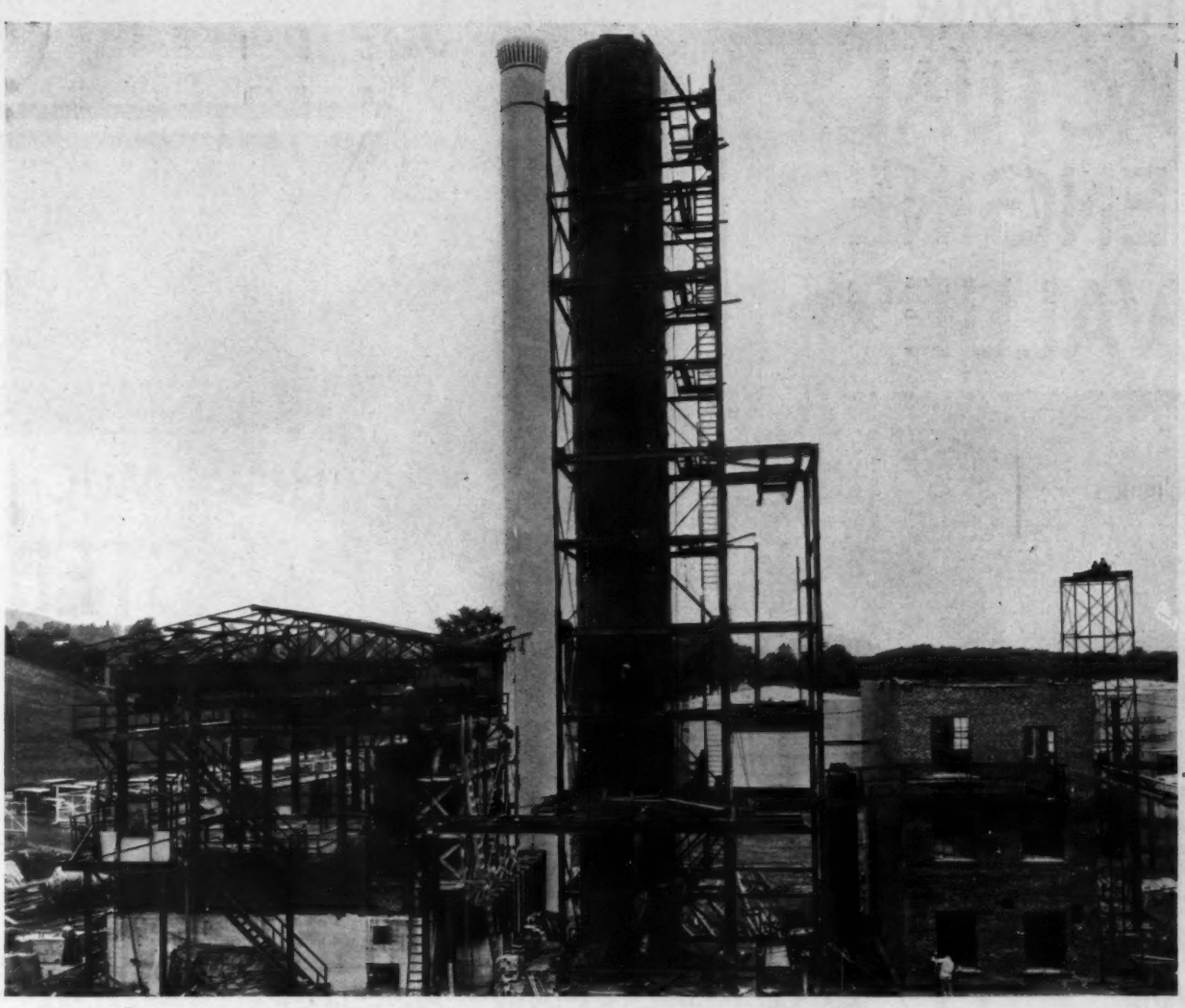


Send for free working sample to test under your own conditions —state full conditions and size packing required for test.

Greene, Tweed & Co.

Sole Manufacturers

109 DUANE STREET NEW YORK



Flexible Rerun Distilling Units

THE single flash Foster Wheeler distilling unit, shown above during erection, will continuously process 8,000 barrels per day of dewaxed products from paraffine base crudes. Flexibility in the design of the unit provides a choice of several commercial operations and the actual operation will depend upon the plant method of dewaxing the lubricating fractions.

The tower is 11 ft. 6 in. in diameter and 115 ft. high. Heat exchangers and vapor condensers will be installed on the steel framework between the tower and receiving house. The tube still, shown at the left, may be fired either with oil or with petroleum coke, pulverized in a Hardinge ball mill.

FOSTER WHEELER CORPORATION

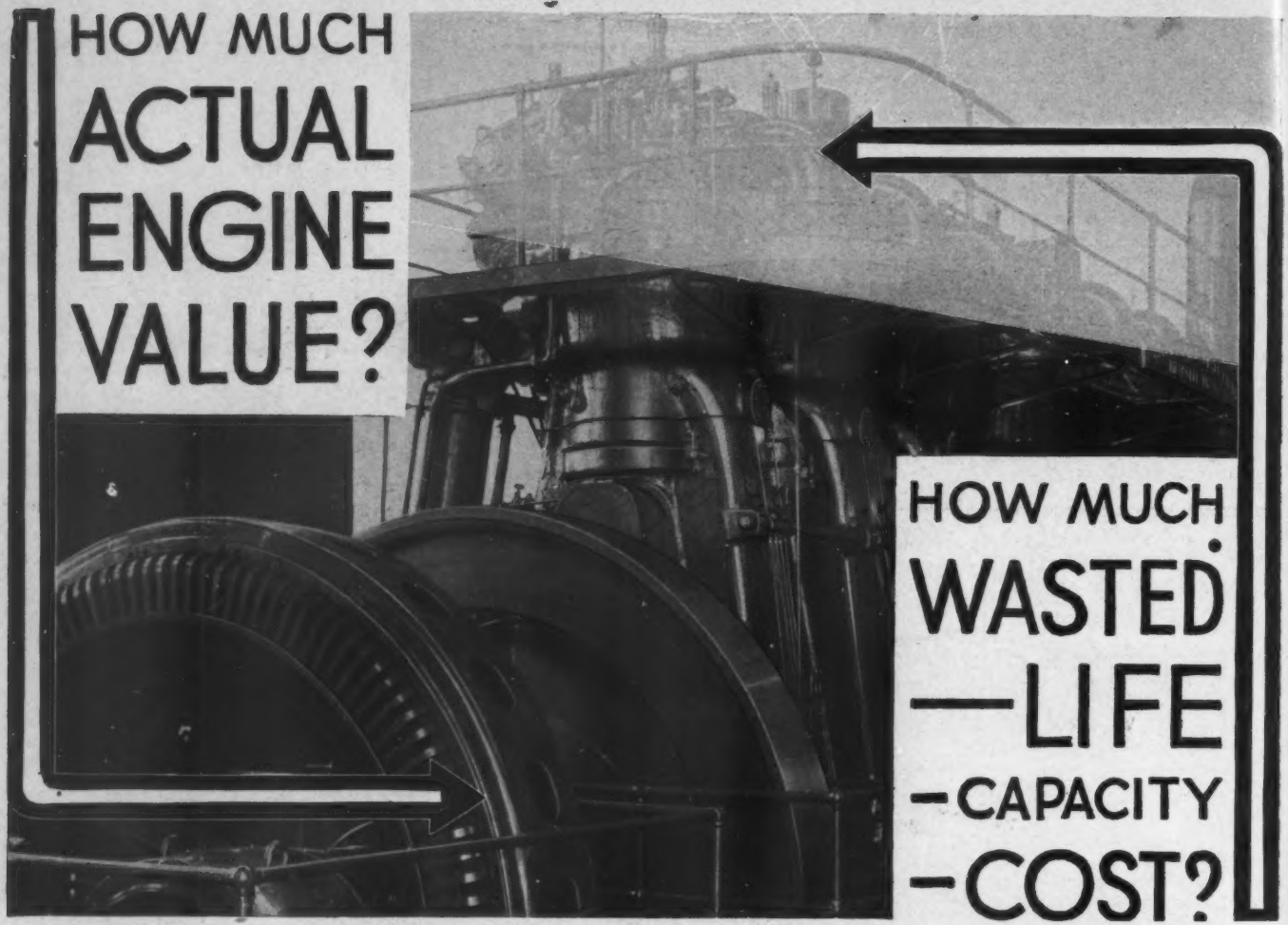
165 Broadway, New York, N. Y.

Branches in Principal Oil Centers

Foreign Associates: Foster Wheeler Limited, London, England
Societe Anonyme Foster Wheeler, Paris, France
Foster Wheeler Limited, Toronto—Montreal, Canada

FOSTER WHEELER

HOW MUCH ACTUAL ENGINE VALUE?



HOW MUCH WASTED —LIFE —CAPACITY —COST?

AMERICAN AIR FILTERS

COMBINING THE PRODUCTS FORMERLY MANUFACTURED UNDER THE FOLLOWING TRADEMARKS:

NATIONAL AIR FILTER NATIONAL TRADE MARK

Reed Air TRADE filters ALL METAL MARK

MIDWEST TRADE MARK

TEXAS UTILITIES COMPANY MAKES SOME DISCOVERIES ABOUT THE EFFECTS OF DUST ON DIESEL ENGINES

BEFORE air filters were installed on the intakes of two large Diesel Engines at the Mexia Plant of the Texas Utilities Company it was customary to take down valves for grinding every 1500 hours. Since the installation of air filters it has been possible to run 3000 hours before cleaning. Former experience showed that a set of cylinder liners costing $2800 had an average life of three years. Cost of labor in installation was about $500 and the loss of engine time serious. The liners installed about the time the filters were installed have served a little over two years and show so little wear that a life of at least four years is predicted. The direct saving in cleaning cost and liner replacement is $466.66 a year and the saving in time, plant operation and engine power is inestimable. (Estimates of savings given here are conservative. In average cases, they should be even greater).

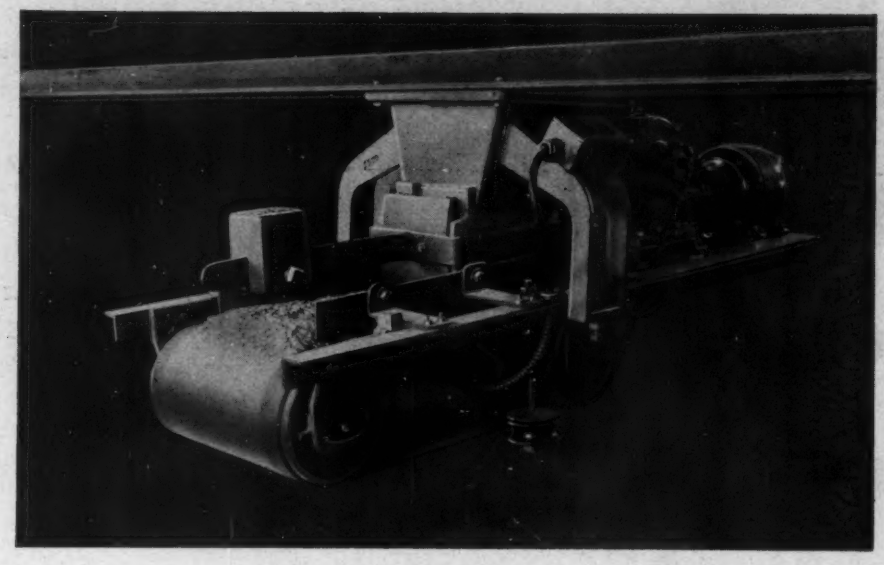
Same Effects On Compressors

Part of the capacity, life and operation of every Diesel Engine and air compressor is made ineffective through dust, unless filtered air is used. Just how much of the margin of value and service of your machinery you will lose depends on thoroughness of air cleaning. We will be glad to send free literature on air filters for compressors and Diesel Engines. Send the coupon. American Air Filter Company, *Incorporated,* Louisville, Kentucky.

HANLON-WATERS INC.

General Offices: TULSA, OKLA. *Box 1404*

HOUSTON FORT WORTH DENVER



Check Your Feeding Operations

If you could increase your capacity—Mixing, Drying, Grinding—only 2%, you would save the price of our Constant Weight Feeder several times over during the year.

It is 10 chances to 1 you can do this, and a lot more. If you are feeding by hand, this automatic weighing device will cut your costs.

This Feeder measures by **weight,** not volume.

It feeds coarse and fine materials without choking.

It eliminates irregularities due to fineness, bin segregation and changes in specific gravity.

It is a self-contained unit, with its own motor, and can be used wherever ordinary electric light is available.

It is reasonable in price.

Write for Bulletin No. 33

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HARDINGE

Conical Ball, Pebble and Rod Mills, Ruggles-Coles Dryers, Thickeners, Clarifiers, Sand Filters

CLARK FEATURES explain the economy and efficiency of "SUPER 2s"

Among the features which have earned popularity for CLARK Engines, are: the new CLARK Variable Load Governor—the CLARK Patented Fuel Saver—Forced Feed Filtered Lubrication to Bearings—Built-In By-Pass—Metallic Packing — Indicator Motion — Die-Forged Connecting Rods.

CLARK BROS. COMPANY have been building oil field engines almost as long as there has been an oil industry — and CLARK Engines have constantly pioneered improvements in design and construction.

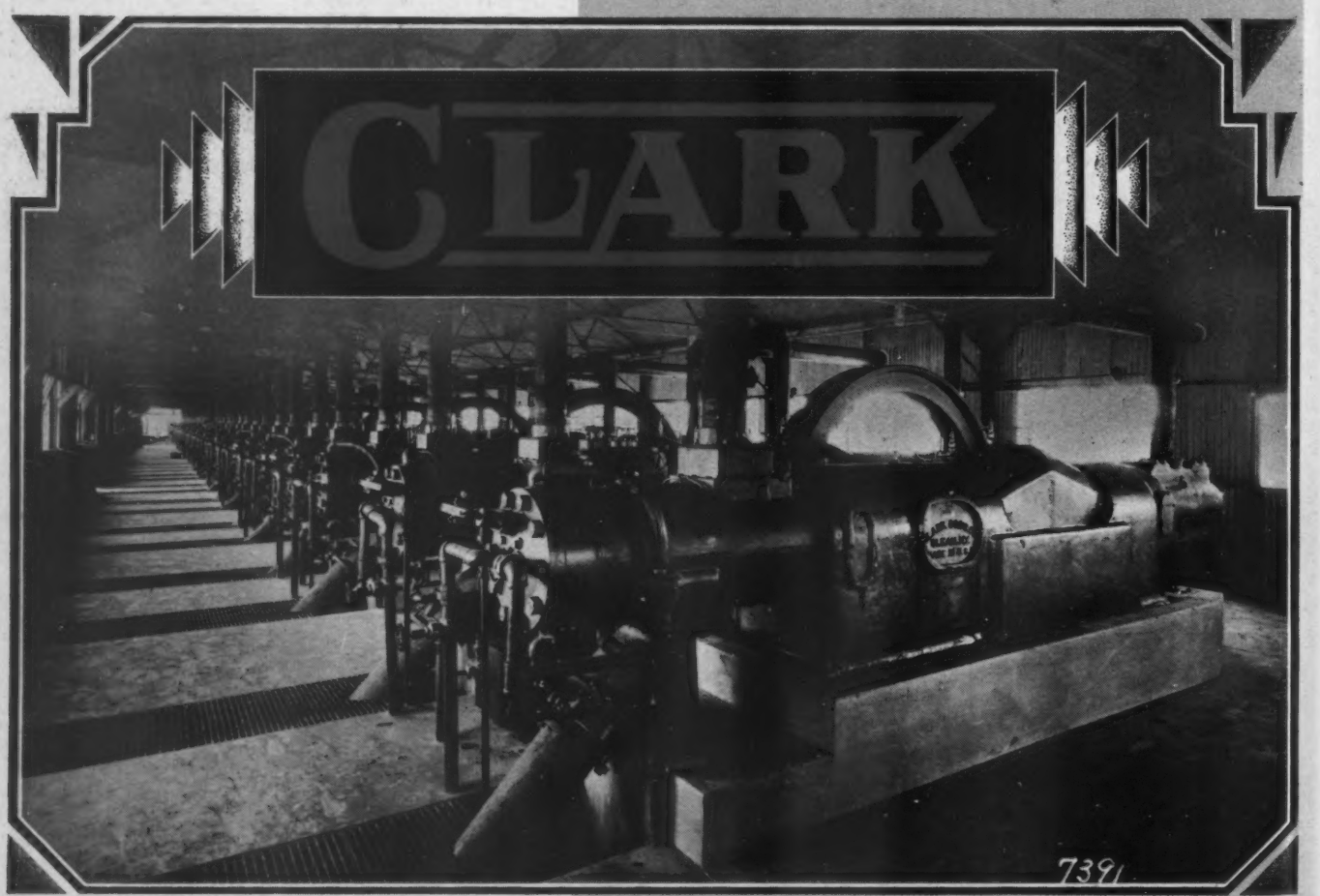
CLARK BROS. COMPANY
OLEAN, N. Y.

Mid-Continent Sales Offices: Tulsa and Fort Worth

Export Office: 150 Broadway New York, N. Y.

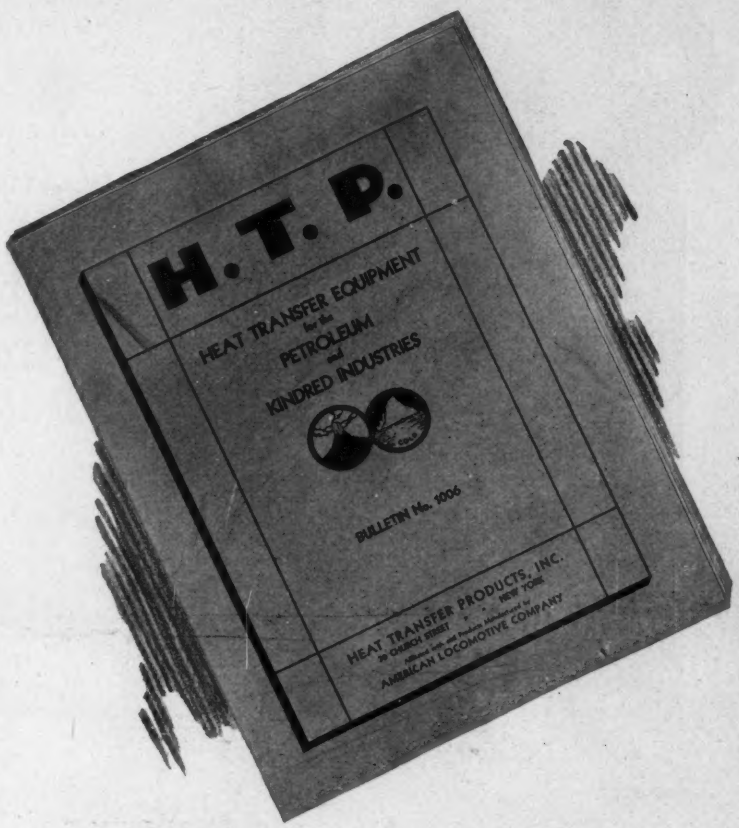
Warehouses: Tulsa; McCamey and Sweetwater, Texas; Artesia, N. M.

California: Smith, Booth, Usher Co., 228 S. Central Ave., Los Angeles.



200 H. P. Clark Super 2s in the Phillips Petroleum Corp. North Plant, Pampa, Texas.

H. T. P.
PRESENTS



.....Bulletin 1006 describing H. T. P. Exchangers for the Petroleum and Kindred Industries.

It also contains useful information regarding economic exchanger selection.

If you have not already received your copy, please write for one.

HEAT TRANSFER PRODUCTS, INC.

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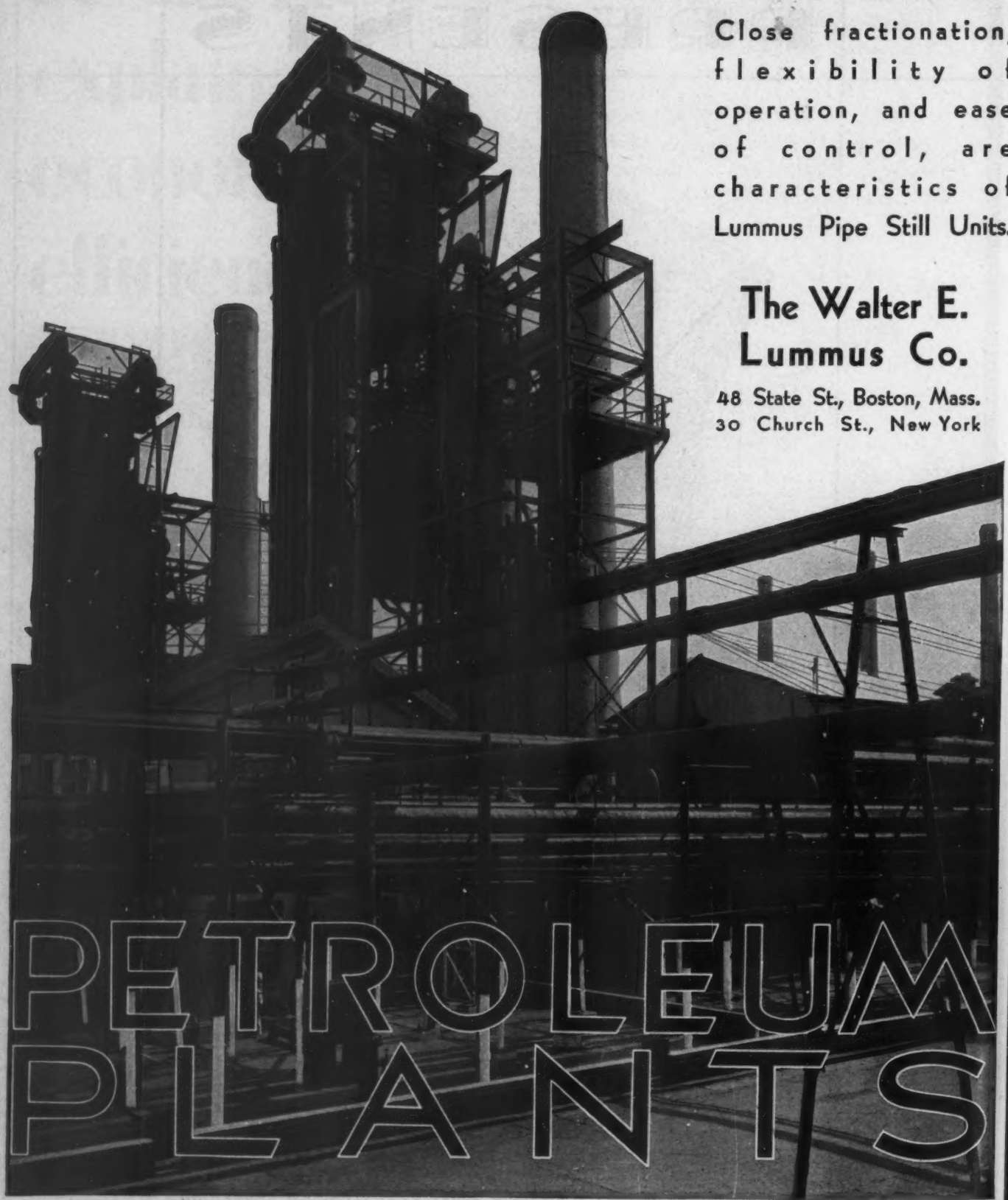
Affiliated with and Products Manufactured by

AMERICAN LOCOMOTIVE COMPANY

TULSA	CHICAGO	CLEVELAND
McBirney Bldg.	McCormick Bldg.	Terminal Tower Bldg.

LUMMUS



Close fractionation, flexibility of operation, and ease of control, are characteristics of Lummus Pipe Still Units.

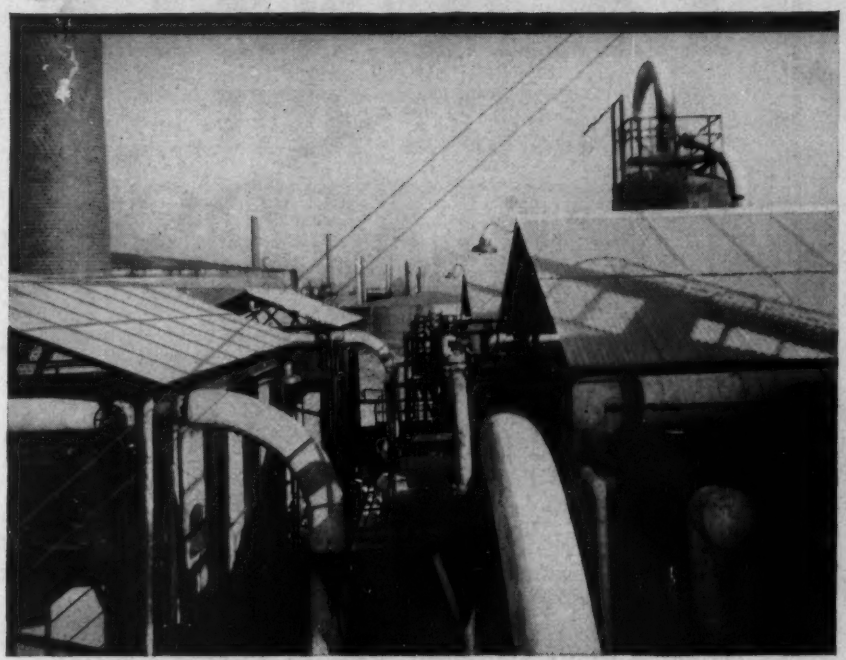
The Walter E. Lummus Co.

48 State St., Boston, Mass.
30 Church St., New York

PETROLEUM PLANTS

JOHNS-MANVILLE JM PRODUCTS

SERVING THE NEEDS OF THE OIL INDUSTRY



The tube-still furnace wall in this Gyro Cracking Unit is insulated with J-M Superex Blocks. J-M Flat Transite provides a fireproof, fume-resisting furnace casing. Corrugated Transite forms a permanent, fireproof, weatherproof roof for the tube-stills. All lines throughout the process are covered with J-M Superex and 85% Magnesia Pipe Insulation.

in . . .

THE OIL FIELD • THE PIPE LINE STATION • THE REFINERY

IN every operation concerned with the production, transport, refining and marketing of gasoline and oil, Johns-Manville products play their important part in reducing losses and lowering costs.

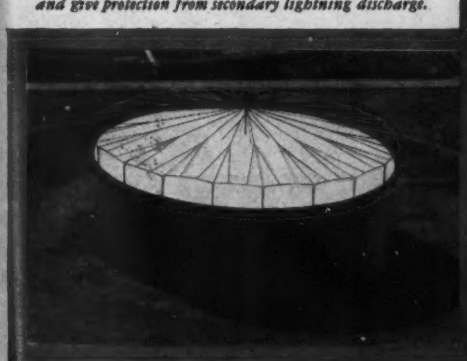
More than seven million barrels of oil and volatile petroluem products are stored in tanks protected from evaporation losses by J-M Vapor-tight Insulated Tank Tops. Miles of underground pipe lines are kept in service years beyond the usual life of such equipment by the use of J-M Pipe Line Felts.

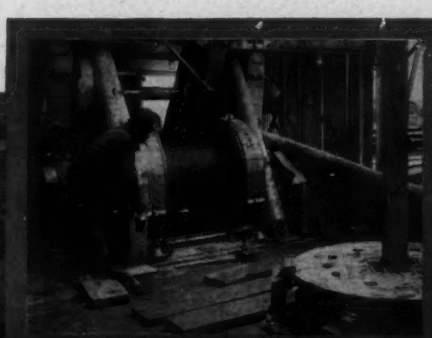
J-M Transite Flare-backs offer an economical control of boil-over fires, and thousands of square feet of this asbestos and Portland Cement combination are used as fire barriers wherever fire hazard is high.

In every department, Johns-Manville Insulations are saving money by conserving heat and in making for better control of the processes involving their use. Stills and towers, steam and oil lines—all operate with better efficiency when insulated by Johns-Manville materials. J-M low temperature insulation protects and seals wax chillers, brine tanks and refrigerating equipment from outside heat.

Complete data on the work we have done for many years for practically every kind of oil industry equipment are the basis for any recommendations we make to you.

J-M Insulated Tank Tops equipped with J-M Grounded Conductor Network reduce evaporation losses and give protection from secondary lightning discharge.





Better control . . . longer life . . . greater safety for oil well machinery is assured by J-M Asbestos Brake Linings and Brake Blocks—write for prices.

Flare-backs built of Transite provide economical, efficient protection against fire spread from tank boil-overs. Inexpensive to erect — no cost for upkeep.

Johns-Manville

SERVICE TO THE OIL INDUSTRY

Address JOHNS-MANVILLE *at nearest office listed below*

New York Chicago Cleveland San Francisco Toronto

(Offices in all large cities)

Will you please have an engineer call to discuss Insulation.

01-54-12

Name.....*Address*.....

Order TRANSIT HOT OIL PUMPS Now

Right now we have the engineering talent and manufacturing facilities available to give you the best of service, and you will get your pumping equipment in plenty of time for installation before the Spring rush of the refining business. Last Winter we worked day and night to keep up with the orders for TRANSIT Hot Oil PUMPS, but even then we were unable to meet the demand.

Put your plant in Competitive Condition by installing TRANSIT Hot Oil PUMPS

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Page Fence

A new, longer lasting fence

ALUMINUM

The metal that lasts indefinitely and *never* needs a painting

Page Fence is always up-to-date. And now that the wonderful weather-resisting properties of Alcoa ALUMINUM find wide-spread use in architecture and the industries, Page engineers have come forward with a non-rusting ALUMINUM Fence.

In the long run it is a most economical fence for it never rusts, never requires a protective coat of paint. It is as near everlasting as any fence you can buy at any price.

For industrial properties such as refineries, our engineers recommend Page ALUMINUM fence as offering the highest degree of protection at the lowest cost per year.

Fencing experts at 64 Page Service Plants will be glad to go into full detail regarding Page ALUMINUM and other Page fencing. They will help in selection and tend to erection of the kind of Page Fence best suited to your needs. Write for the address of the nearest service plant and further information concerning Page Fence of "the New Metal"—ALUMINUM. Page Fence Association, 520 North Michigan Ave., Dept. B48, Chicago, Illinois.

PAGE

America's first—since STEEL AND WIRE PAGE QUALITY PRODUCTS *wire fence 1883*

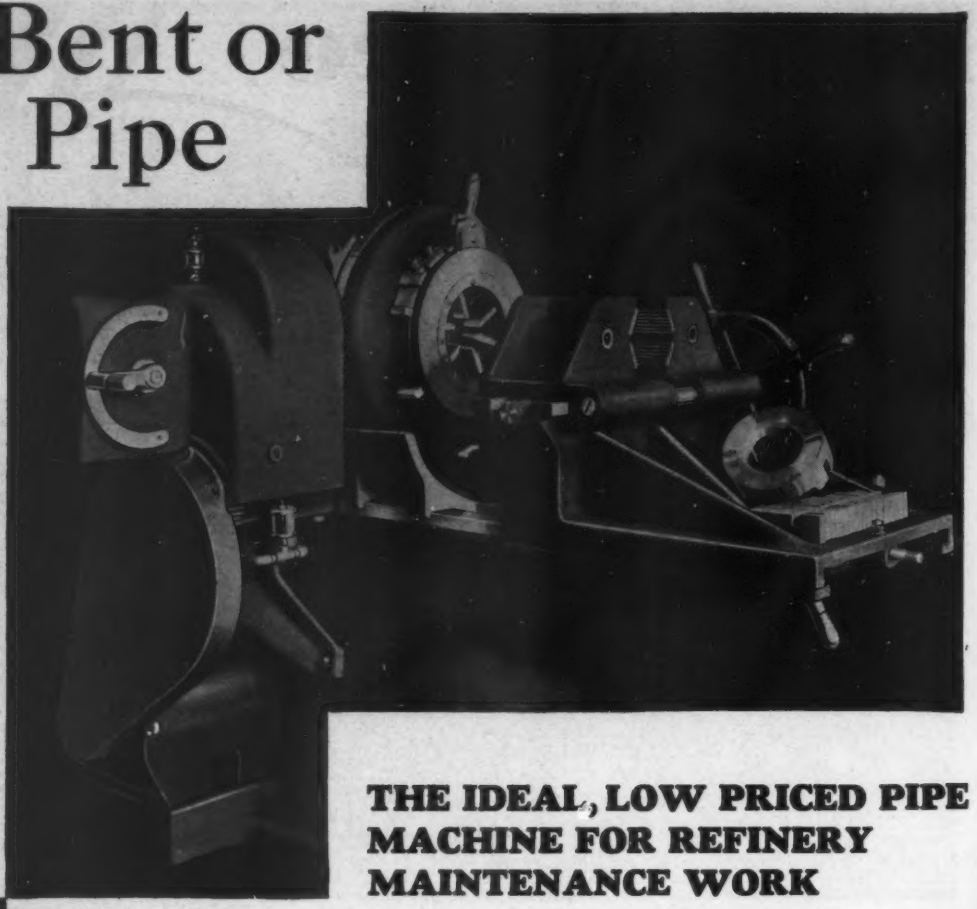
Fence of Armco Ingot Iron fabric is exclusive with Page

FENCE

Page Fence is a Product of The Page Steel & Wire Co., an Associate Company of American Chain Co., Inc.

CHAIN LINK OR ORNAMENTAL WROUGHT IRON

Thread Bent or Straight Pipe



THE IDEAL, LOW PRICED PIPE MACHINE FOR REFINERY MAINTENANCE WORK

The open type vise that permits you to thread long, short or bent pieces of pipe with equal ease; the rotary die-head; the few working parts; the fountain flood oiling system that insures perfect lubrication; the automatic die release which permits you to cut 10 or 10,000 threads to a uniform pre-determined length; the automatic feed cut-off tool—these are a few of the many features exclusive to Oster Power Machines that have made them preferred for refinery maintenance work where a versatile, dependable, low-priced maintenance machine is desired for ¼″ to 8″ pipe threading and cutting-off jobs.

Detailed information describing these features in full and explaining why they will save time, labor and materials in your pipe shop, will be sent to you promptly on request.

OSTER

WILLIAMS TOOL CORPORATION

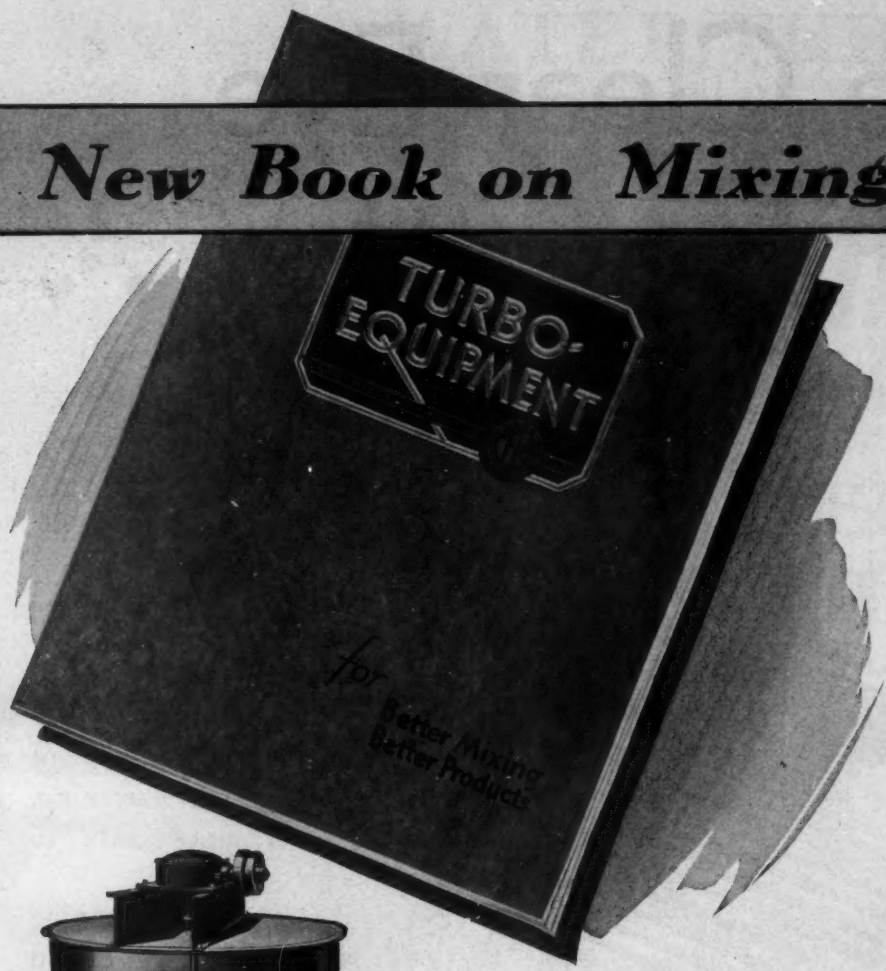
THE OSTER MANUFACTURING COMPANY JOINED FOR GREATER SERVICE WILLIAMS TOOL CORPORATION

Sales Offices—2067 East 61st Place, Cleveland, Ohio

Branch Offices—Boston, New York, Philadelphia, Chicago

The Oster Power Machines are a part of the most complete line of hand and power operated pipe threading equipment in the world.

A New Book on Mixing



Turbo-Mixers are adapted to all mixing operations. The action of the Simplex and Triplex Types is illustrated herewith. A Turbo Mixing Unit consisting of a Duplex Impeller and Curved Deflecting Blade Ring, is shown below.

THE new book on Turbo-Equipment is designed to present for the first time in print, the newest ideas on processes such as mixing, agitation, heat transfer, gas absorption.

The ideas discussed have been thoroughly tested in the laboratory and in many of America's best known plants.

Every engineer and executive will find this book at least thought stimulating, probably of direct value, possibly the key to major economies.

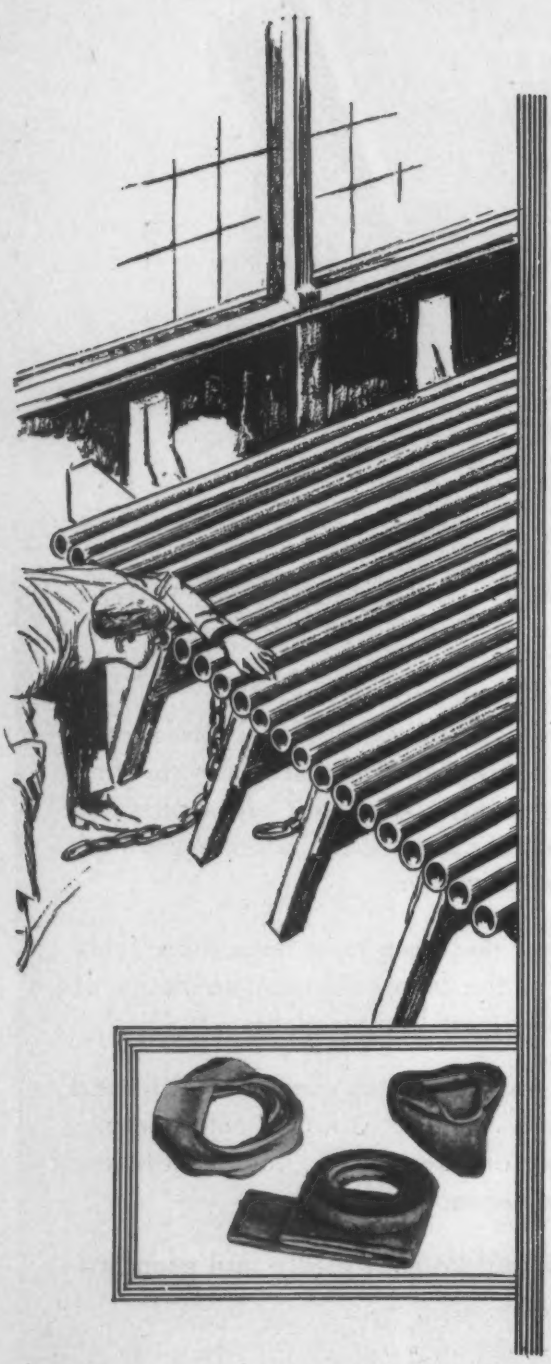
A copy will be sent gladly and promptly on request.

TURBO-MIXER CORPORATION

CRYSTAL BLDG., 43RD STREET AT 2ND AVE., NEW YORK, N. Y.

4925

The Clear Eye of Inspection



EACH Pittsburgh Seamless Boiler Tube is rigidly inspected . . . from start to finish . . . for possible flaws.

Steel of the proper chemical analysis is carefully selected.

Check analysis is taken on drillings of the finished tubes.

Test specimens from each run of tubes are subjected to flattening, flanging and crushing tests to assure proper ductility.

Every tube must pass exacting tests for diameter, gauge and length.

Each tube individually must pass a hydrostatic test to a minimum pressure of 1,000 lbs. per square inch . . . or higher, as specifications demand.

More than twenty-five years of experience in the manufacture of seamless steel pipe and tubing exclusively, are behind every Pittsburgh Seamless Steel Boiler Tube . . . and every "Pittsburgh" tubular product.

From ore to Finished Pipe or Tube, Pittsburgh Seamless Pipe or Tubing is the result of one Company's resources and Skill.

Pittsburgh Steel Products Co.

Division of

Pittsburgh Steel Co.

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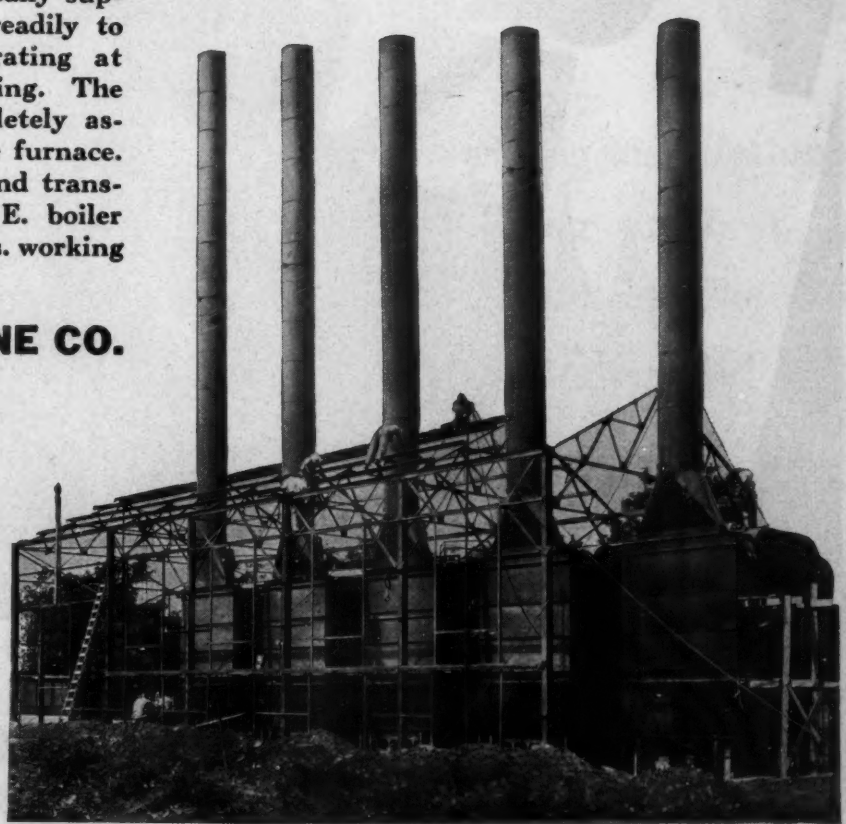
Pittsburgh Seamless

BOILER TUBES · REFINERY PIPING

3028

WATER TUBE Vogt BOILERS *Portable-Type for* OIL FIELD SERVICE

For well drilling, natural gasoline extraction plants and similar operations, Vogt portable curved tube boilers are economically supplying steam. They respond readily to fluctuating loads and are operating at better than 200% continuous rating. The smaller sizes are shipped completely assembled ready to mount on the furnace. They can easily be dismantled and transported when desired. A. S. M. E. boiler construction code for 150 to 300 lbs. working pressure is strictly followed.



HENRY VOGT MACHINE CO.
Incorporated
Louisville, Kentucky

Manufacturers of:
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OIL WELL-FIELD AND REFINERY VALVES

Powell Bronze, Iron and Steel, Globe, Angle, Cross, Check, Gate and Safety Valves have become the adopted standard for oil well, field and refinery service. They are processed to be oil and gas tight; they are adapted for handling volatile and hazardous liquids and gases. Powell Valves are made in a full range of types and sizes for working pressures of 125 pounds to 2000 pounds - - - for temperatures to 1250° F.

THE WM. POWELL CO.
2521-2531 Spring Grove Ave., Cincinnati, Ohio

POWELL

VALVES

. . . WHERE IS MAINTENANCE IN PIPING? . .

All maintenance and upkeep work in piping installations is at the joints. Progressive engineers, demanding the best in present day pipe fabrication, have adopted oxwelding. The oxwelded joint is strong, leakproof and permanently tight—100 per cent efficient . . . It eliminates joint maintenance.

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58% SODA ASH

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Solid—Flake—Ground—Liquid

Leading refiners depend on these products for the quality and uniformity which industry inevitably associates with the name Solvay. First in pioneering the development of American sources of alkali, The Solvay Process Company is recognized as the outstanding leader of its field—first in size and first in facilities for rendering efficient service.

Strategically located distributing points ensure prompt delivery of Solvay products with minimum transportation charges.

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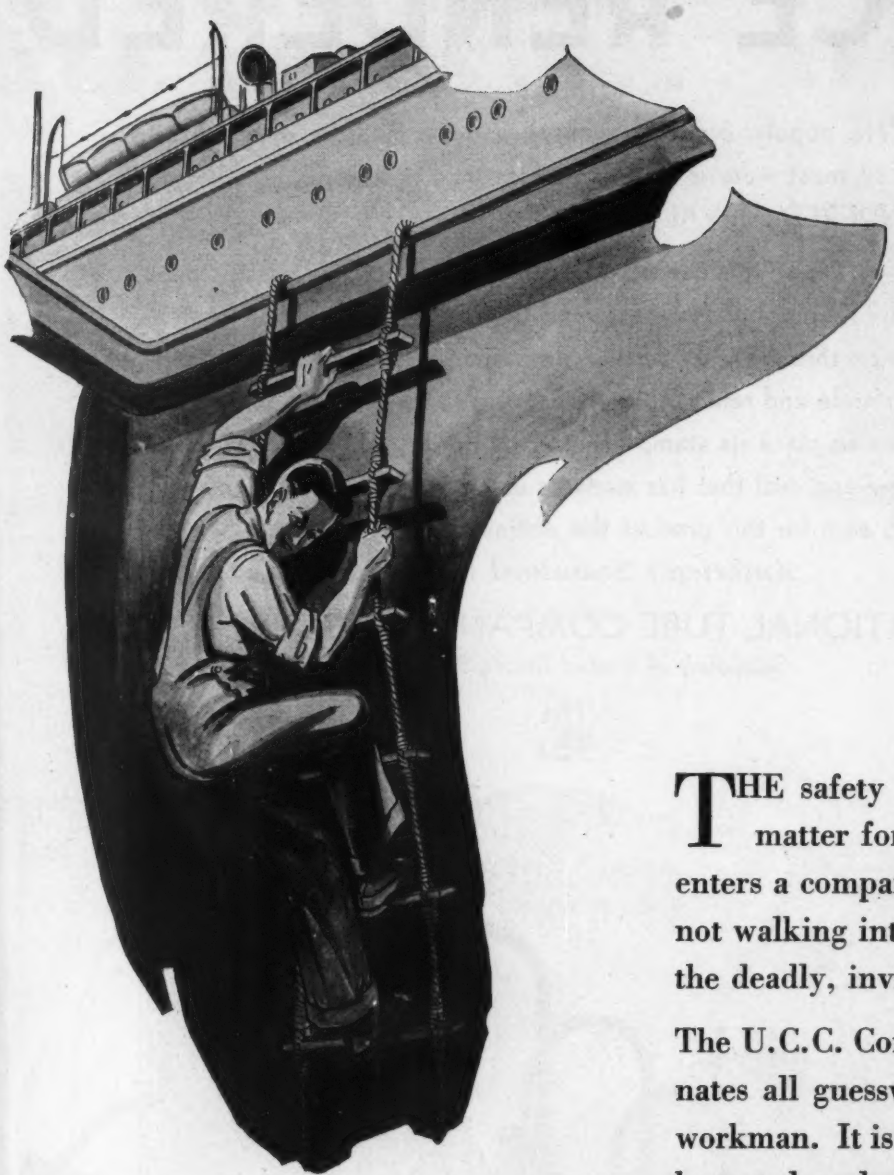

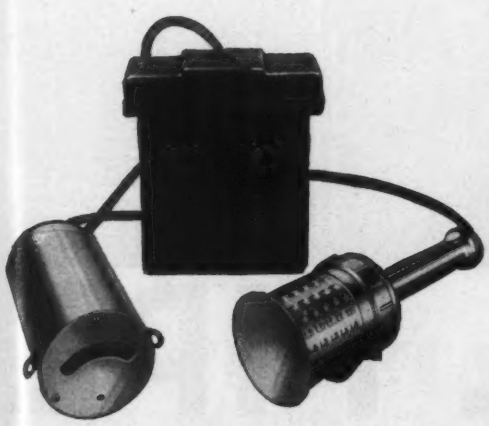

The U.C.C.
Combustible Gas Indicator

THE safety of life and property is not a matter for guesswork. A workman who enters a compartment must be sure that he is not walking into an atmosphere that contains the deadly, invisible hazard—flammable gas.

The U.C.C. Combustible Gas Indicator eliminates all guesswork in the protection of this workman. It is carried into the atmosphere to be tested, and gives direct, immediate warning of the presence of flammable gases.

Return the coupon below for a booklet describing the U.C.C. Indicator and its applications.

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UNION CARBIDE SALES COMPANY

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Union Carbide Sales Co., Safety Appliance Department, 30 East 42nd St., New York, N. Y.
Please send me your new booklet about the U. C. C. Combustible Gas Indicator.

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THE popular proof of quality—and the measure by which, after all, most store is set—is performance on the job . . . SERVICE RENDERED . . . VALUE RECEIVED!

It was on this basis that NATIONAL Pipe, early in the history of the refining industry, assumed leadership in the field. From that time on through the years of development to its present state of magnitude and remarkable efficiency, the refining industry has continued to place its stamp of approval on the merits of NATIONAL Pipe—approval that has made its use so generous and country-wide as to earn for this product the distinction of—

America's Standard Wrought Pipe

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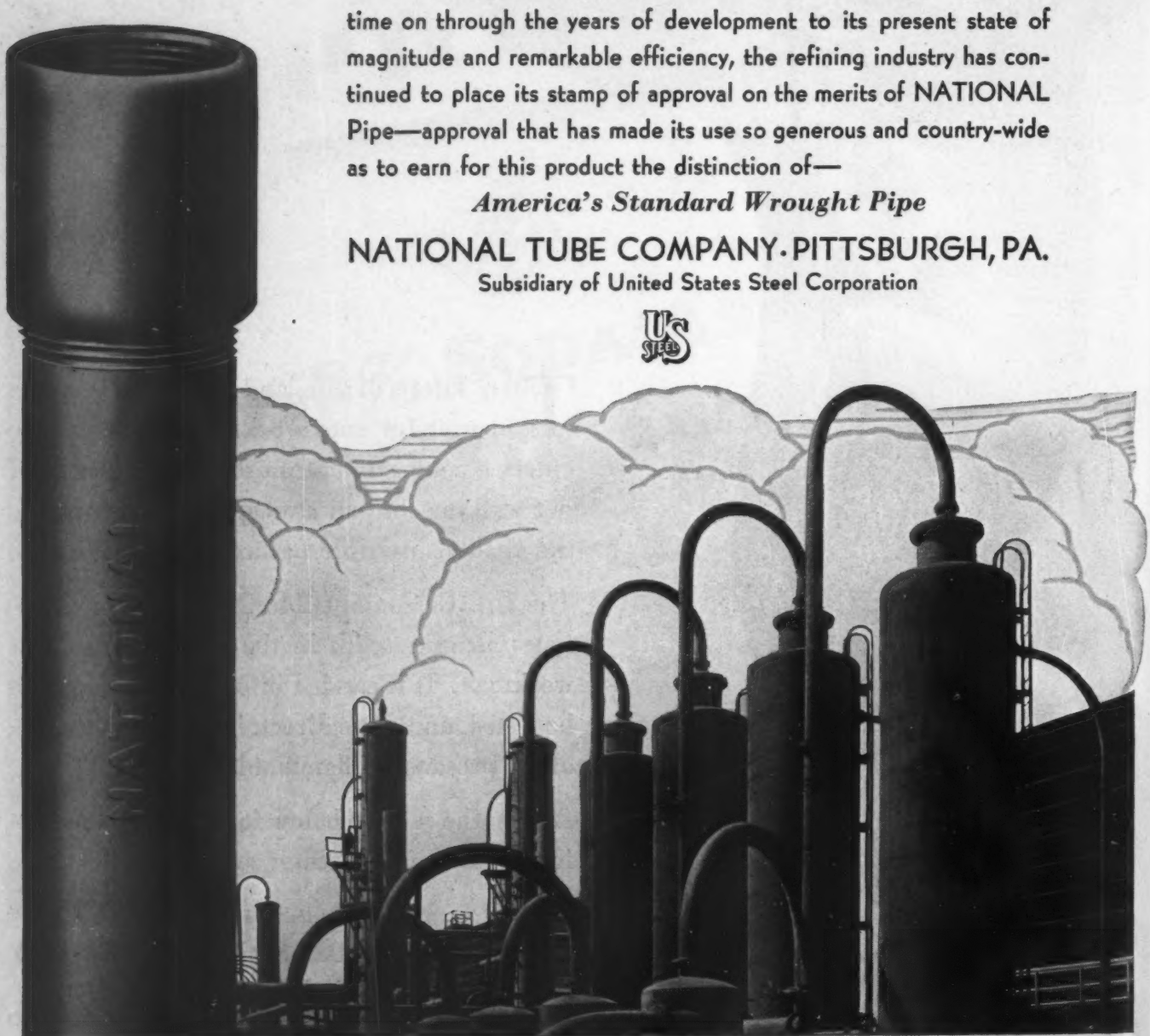

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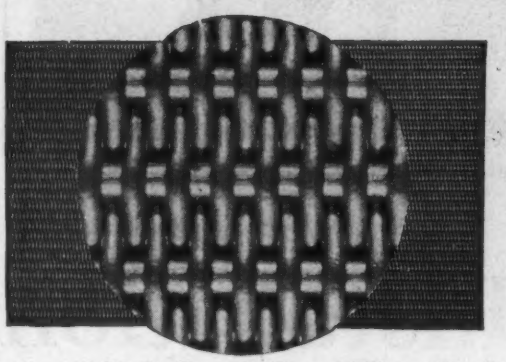
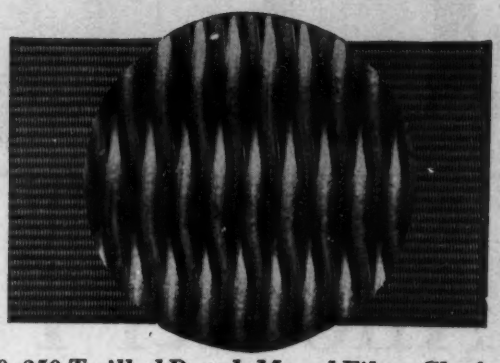
FILTER CLOTH
ALL TYPES . . . . . ALL METALS



24 x 110 Plain Dutch Monel Filter Cloth

CIRCLES SHOW SCREEN MAGNIFIED 12 DIAMETERS



20x250 Twilled Dutch Monel Filter Cloth

Wire screens of precision, great lasting qualities and corrosion resistance for: flame arrestors, vapor phase treating towers, percolating filters and contact filter presses.

Filter cloth up to 10 feet wide.

Service department for cutting screens to shape, spot-welding, binding, making-up complete filter blankets, and covering filter presses.

All types of mesh and weave in . . .

Aluminum, Allegheny Metal, Ascoloy, Brass, Enduro-Nirosta, Everdur, Monel, Multalloy, Nichrome, Phosphor Bronze, Pure Swedish Iron, Pure Nickel, Steel, Tinned Cloth.

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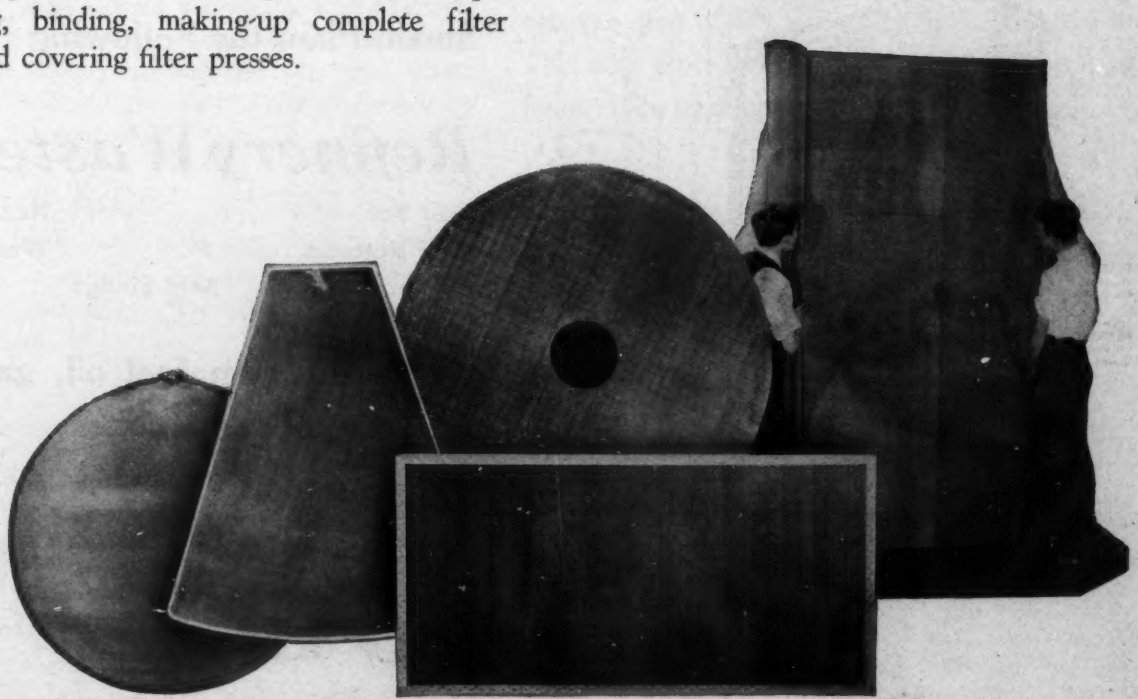

MULTI-METAL WIRE CLOTH CO., *Inc.*

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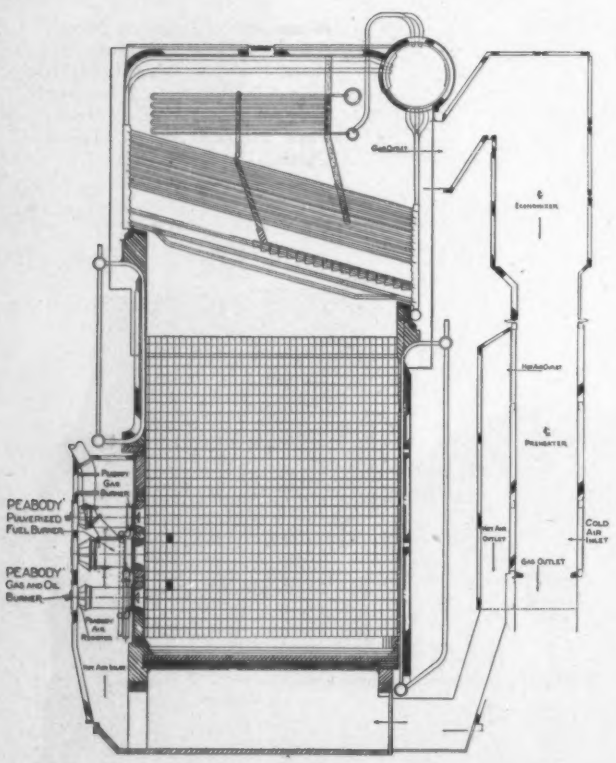
BURNERS

PEABODY

Another Pioneer Installation

At the Baton Rouge Station of Louisiana Steam Products, Inc., Stone & Webster Engineering Corporation, engineers and builders.



70 Peabody Combined Burners Under Four 1382 H.P. Boilers Operating at 750 Per Cent of Builder's Rated Capacity are Firing for the First Time in a Modern Steam Plant the Following

Refinery Waste Fuels

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Soda Bottoms
Neutralized Sludge
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and in addition fuel oil, gas and pulverized petroleum coke.

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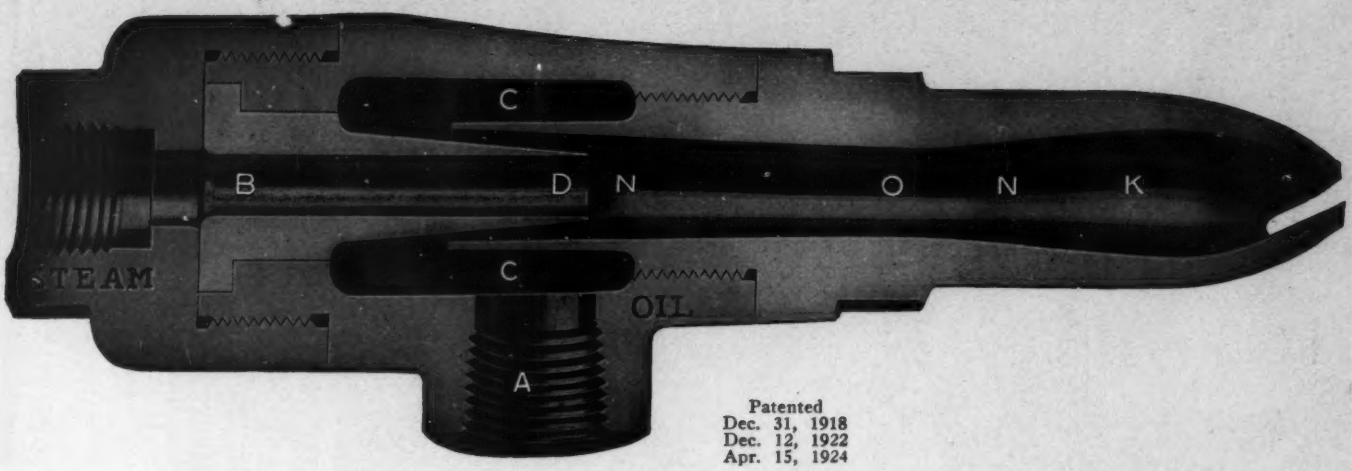
National Airoil Burners



Patented
Dec. 31, 1918
Dec. 12, 1922
Apr. 15, 1924

For Power Plants and Stills and all Industrial Furnaces

NATIONAL AIROIL BURNERS
are internal atomizing burners—inside mixers —operating with either steam or compressed air; and burn as steady as a gas flame with any grade of fuel. Set your fire the way you want it, and it will burn the day through without watching or readjusting.

NATIONAL AIROIL BURNERS
will handle the heavy residuum from cracking stills without requiring continual removal for cleaning, an immense factor in economical plant operation.

NATIONAL AIROIL BURNERS
when operating under boilers will use less than one per cent of the steam for atomizing the oil. The old style steam atomizing burners use from three to seven per cent.

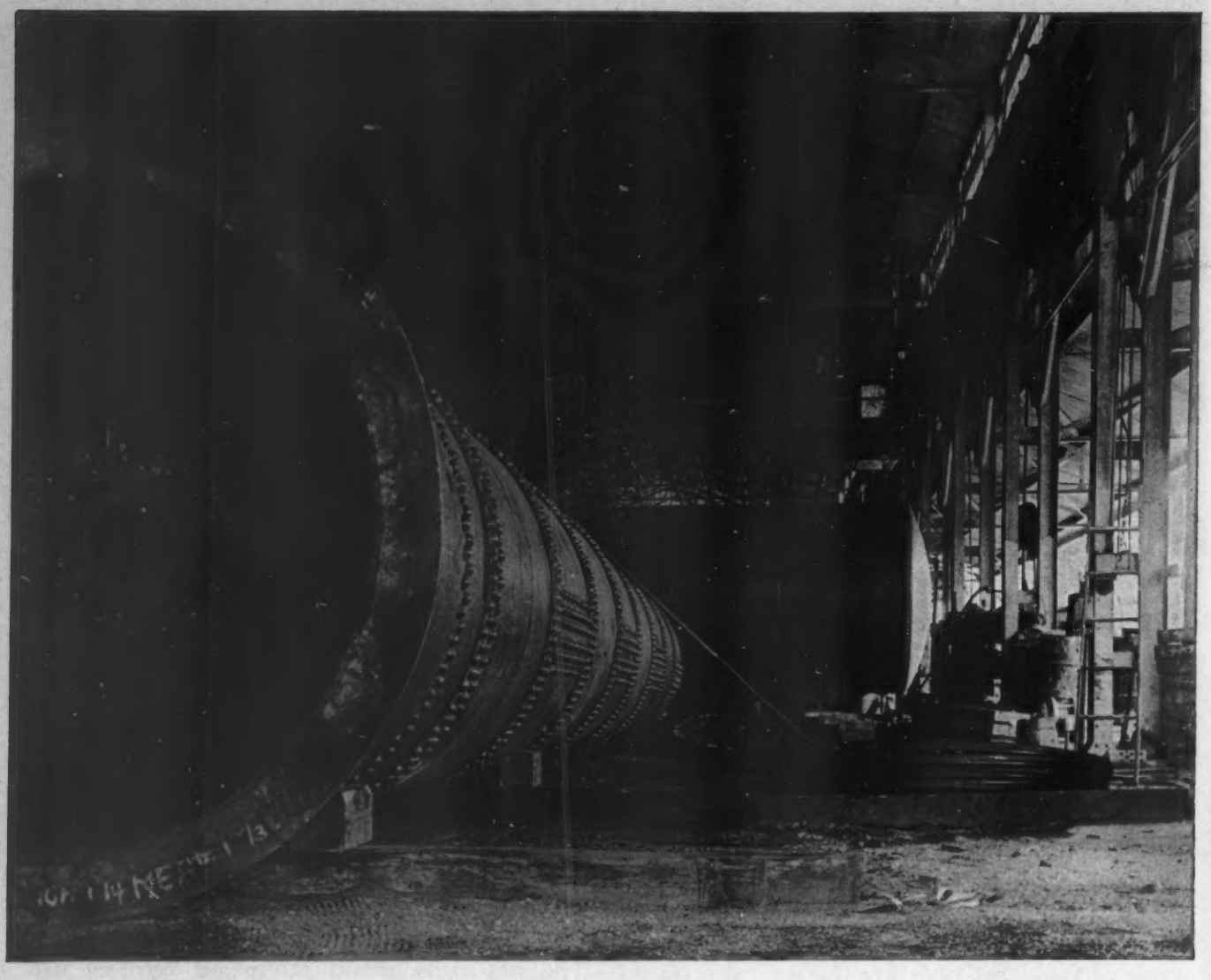
NATIONAL AIROIL BURNERS
give a soft gaseous flame that does not injure brick work or boiler tubes. Made with flat or round tips.

Write for our Bulletin No. 21

National Airoil Burner Company

Factory: S. W. Cor. 9th and Thompson Sts.
Sales Rooms: 1327 Girard Avenue
PHILADELPHIA, PA.

Oil Burners and Oil Burning Equipment



On heavy plate work for refineries, natural gasoline plants or other uses in the oil industry, the two big plants of Wyatt at Dallas and Houston can serve you adequately. The Wyatt plants have the equipment, the manpower and the experience to translate your specifications into a complete job that meets all requirements. . . . Lower Freight Rates . . . Quicker Service

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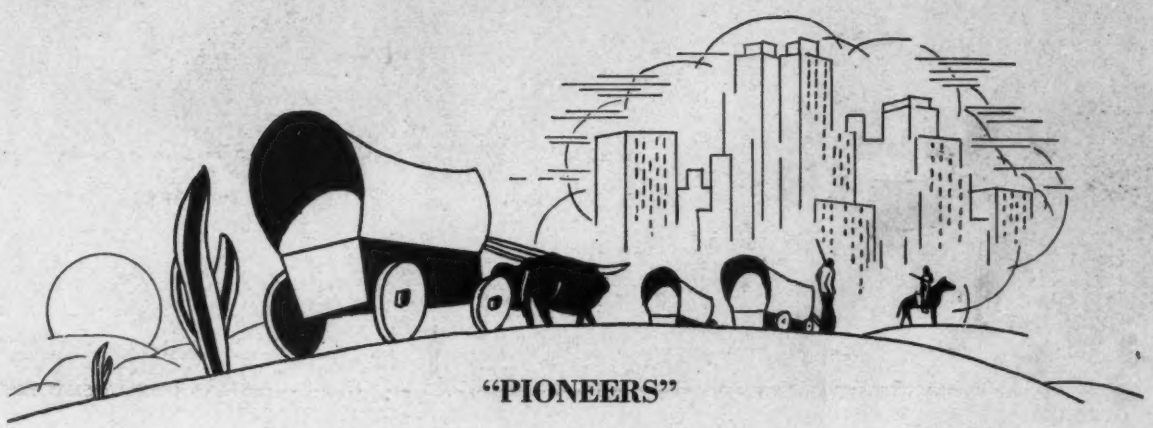
PLANTS AT DALLAS AND HOUSTON



"PIONEERS"

The manufacturers of PIONEER OYSTER-SHELL LIME *wish to express their appreciation of the courtesies shown them during 1930, and extend to all their friends in the oil refining industry the most hearty and sincere wishes for*

A Merry Christmas

and

A Prosperous New Year

If there is any way in which we can help you to improve or increase business during 1931, please call on us. It will be a real pleasure to serve you.

THE HADEN LIME COMPANY
MFRS. OF PIONEER OYSTER SHELL LIME
1720 SHEPHERD STREET
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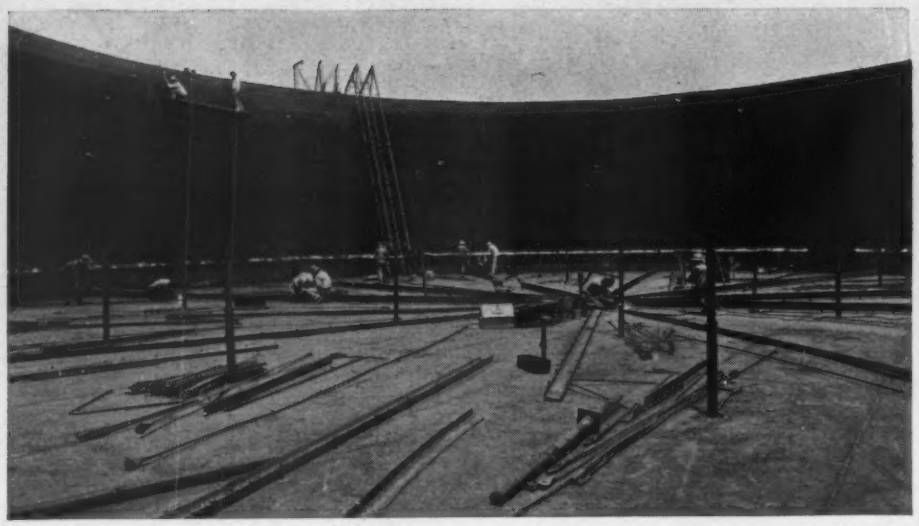
PROGRESS

TRADITION



"MY observation has been that most of the tank builders are using the Lincoln 'Stable-Arc' welder on the roofs and bottoms of tanks.

Don't tell me that so many men will share a common preference."

"True, but this is no *common* preference, Pop.

An automatic idling device that effects a 25% saving in fuel consumption is not common to all welders — it's an exclusive Lincoln development.

An all welded steel frame and welded steel canopy with welded steel removable side and end panels for protection against the elements and meddlers is not common welder construction.

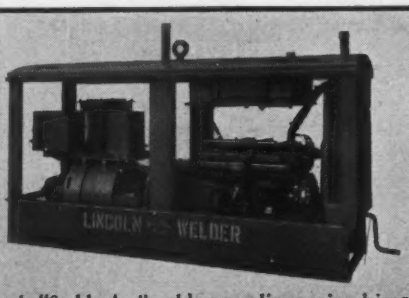
The stability of the Lincoln arc is not common to welders—it is UNUSUAL and gives operators a chance to produce faster and better welding.

And that's why operators prefer the Lincoln 'Stable-Arc'—why it has been used on the *majority* of arc-welded pipe lines — and why the Lincoln machine has this wide appeal to the crude as well as to the refined (speaking in oil terms)."

THE LINCOLN ELECTRIC COMPANY
Department No. 34-12 Cleveland, Ohio
World's Largest Manufacturers of Arc Welding Equipment

W-162

LINCOLN "Stable-Arc" WELDER



Lincoln "Stable-Arc" welders gasoline engine driven type are built in 200, 300, 400 and 600 ampere sizes.

84" x 33'9" Welded Butane Gas Receiver, built by Biggs. Working pressure 200 pounds. Weight, 34,500 pounds.

Biggs Welded Receivers, Stills, Fractionating Towers and Similar Retorts Insure Maximum Safety and Minimum Maintenance . .

SAFE BIGGS WELD DUCTILE UNIFORM STRONGER THAN THE PLATE ITSELF Biggs

"Built by Biggs"
for the
Petroleum Industry

Welded High Pressure Storage Tanks
Riveted High Pressure Storage Tanks
Bulk Storage Tanks
Gas Receivers
Scrubbers
Stills — Absorbers
Agitators — Towers
Miscellaneous Steel Plate Construction — Welded or Riveted

BIGGS has furnished one customer ten 84"x33'9" high pressure butane receivers. They were installed during December, 1929, and January of this year. The customer writes:

"Since these dates the tanks have been in practically continuous service, storing butane-propane mixtures and high test gasoline. The tanks were purchased for 200 pounds working pressure, but on one or two occasions have had pressures in excess of 225 pounds on them for short periods of time. The tanks are painted with aluminum paint and are uninsulated. To date we have experienced no difficulties with them, nor seen any evidence of leakage, seepage, strain or structural weakness of any description."

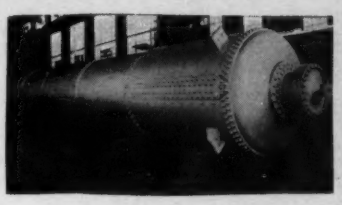
Biggs electrically welded high pressure vessels are built under a procedure control recognized and accepted by the leading insurance companies. They are accepted for installation in sizes beyond the restrictions of the A. S. M. E unfired pressure vessel code. Biggs welded vessels are safe, uniform, dependable. They can be accepted with the same confidence as has been accorded Biggs riveted construction for many years.

THE BIGGS BOILER WORKS COMPANY, AKRON, OHIO
New York — Detroit

Welded Fractionating Tower

Welded Absorber

Anhydrous Ammonia Receiver



Scrubber Tank, Welded or Riveted

Oil Still, Welded or Riveted

Standard Tanks in Stock

Steel Penstocks, Riveted or Welded

BOILER WORKS CO. The Biggs EST. 1857 AKRON OHIO

Trade Mark Registered

TANKS AND GENERAL
STEEL PLATE WORK

How much gasoline *Stays in the tank car?*

An amazing amount of it escapes unless a Universal Gastite Dome Cover is used. 100 to 400 gallons per car is not unusual. Hot days take as high as 800 gallons.

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This saving, plus the material reduction of dangers incidental to loading, and the ability to load 24 hours a day, rain or shine, makes McDonald Universal Gastite Dome Covers absolute necessities for the safe, economical loading of gasoline.

Made for every type of tank car. Write today for complete information.

A. Y. McDONALD MFG. CO.

"The Home of the Swing Joint"

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"There's a McDonald Distributor Near You"

Plate 864
McDonald Gastite Dome Covers
(Patented 10-14-1924)

McDONALD